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Am29DSI63D

Data Sheet

July 2003

The following document specifies Spansion memory products that are now offered by both Advanced Micro Devices and Fujitsu. Although the document is marked with the name of the company that originally developed the specification, these products will be offered to customers of both AMD and Fujitsu.

Continuity of Specifications

There is no change to this datasheet as a result of offering the device as a Spansion product. Any changes that have been made are the result of normal datasheet improvement and are noted in the document revision summary, where supported. Future routine revisions will occur when appropriate, and changes will be noted in a revision summary.

Continuity of Ordering Part Numbers

AMD and Fujitsu continue to support existing part numbers beginning with "Am" and "MBM". To order these products, please use only the Ordering Part Numbers listed in this document.

For More Information

Please contact your local AMD or Fujitsu sales office for additional information about Spansion memory solutions.

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ADVANCE INFORMATION

Am29DS163D

16 Megabit (2 M x 8-Bit/1 M x 16-Bit) CMOS 1.8 Volt-only, Simultaneous Operation Flash Memory

DISTINCTIVE CHARACTERISTICS

ARCHITECTURAL ADVANTAGES

- **Simultaneous Read/Write operations**
  - Data can be continuously read from one bank while executing erase/program functions in other bank
  - Zero latency between read and write operations
- **Multiple bank architectures**
  - Two devices available with different bank sizes (refer to Table 3)
- **Secured Silicon (SecSi) Sector**
  - *Factory locked and identifiable:* 16 bytes available for secure, random factory Electronic Serial Number; verifiable as factory locked through autoselect function. ExpressFlash option allows entire sector to be available for factory-secured data.
  - *Customer lockable:* Can be read, programmed, or erased just like other sectors. Once locked, data cannot be changed.
  - 64 Kbyte sector size
- **Zero Power Operation**
  - Sophisticated power management circuits reduce power consumed during inactive periods to nearly zero
- **Package options**
  - 48-ball FBGA
- **Top or bottom boot block**
- **Manufactured on 0.23 µm process technology**
- **Compatible with JEDEC standards**
  - Pinout and software compatible with single-power-supply flash standard

PERFORMANCE CHARACTERISTICS

- **High performance**
  - Access time as fast 100 ns
  - Program time: 13 µs/word typical utilizing Accelerate function
- **Ultra low power consumption (typical values)**
  - 1 mA active read current at 1 MHz
  - 5 mA active read current at 5 MHz
  - 200 nA in standby or automatic sleep mode
- **Minimum 1 million write cycles guaranteed per sector**
- **20 Year data retention at 125°C**
  - Reliable operation for the life of the system

SOFTWARE FEATURES

- **Data Management Software (DMS)**
  - AMD-supplied software manages data programming and erasing, enabling EEPROM emulation
  - Eases sector erase limitations
- **Supports Common Flash Memory Interface (CFI)**
- **Erase Suspend/Erase Resume**
  - Suspends erase operations to allow programming in same bank
- **Data# Polling and Toggle Bits**
  - Provides a software method of detecting the status of program or erase cycles
- **Unlock Bypass Program command**
  - Reduces overall programming time when issuing multiple program command sequences

HARDWARE FEATURES

- **Any combination of sectors can be erased**
- **Ready/Busy# output (RY/BY#)**
  - Hardware method for detecting program or erase cycle completion
- **Hardware reset pin (RESET#)**
  - Hardware method of resetting the internal state machine to reading array data
- **WP#/ACC input pin**
  - Write protect (WP#) function allows protection of two outermost boot sectors, regardless of sector protect status
  - Acceleration (ACC) function provides accelerated program times
- **Sector protection**
  - Hardware method of locking a sector, either in-system or using programming equipment, to prevent any program or erase operation within that sector
  - Temporary Sector Unprotect allows changing data in protected sectors in-system

This document contains information on a product under development at Advanced Micro Devices. The information is intended to help you evaluate this product. AMD reserves the right to change or discontinue work on this proposed product without notice.

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GENERAL DESCRIPTION

The Am29DS163D family consists of 16 megabit, 1.8 volt-only flash memory devices, organized as 1,048,576 words of 16 bits each or 2,097,152 bytes of 8 bits each. Word mode data appears on DQ0–DQ15; byte mode data appears on DQ0–DQ7. The device is designed to be programmed in-system with the standard 1.8 volt V_{CC} supply, and can also be programmed in standard EPROM programmers.

The device is available with an access time of 100 and 120 ns. The devices are offered in an 48-ball FBGA package. Standard control pins—chip enable (CE#), write enable (WE#), and output enable (OE#)—control normal read and write operations, and avoid bus contention issues.

The device requires only a **single 1.8 volt power supply** for both read and write functions. Internally generated and regulated voltages are provided for the program and erase operations.

Simultaneous Read/Write Operations with Zero Latency

The Simultaneous Read/Write architecture provides **simultaneous operation** by dividing the memory space into two banks. The device can improve overall system performance by allowing a host system to program or erase in one bank, then immediately and simultaneously read from the other bank, with zero latency. This releases the system from waiting for the completion of program or erase operations.

Am29DS163D Features

The **Secured Silicon (SecSi) Sector** is an additional 64 Kbyte sector capable of being permanently locked by AMD or customers. The **SecSi Sector Indicator Bit** (DQ7) is permanently set to a 1 if the part is **factory locked**, and set to a 0 if **customer lockable**. This way, customer lockable parts can never be used to replace a factory locked part.

Factory locked parts provide several options. The SecSi Sector may store a secure, random 16 byte ESN (Electronic Serial Number), customer code (programmed through AMD's ExpressFlash service), or both. Customer Lockable parts may utilize the SecSi Sector as bonus space, reading and writing like any other flash sector, or may permanently lock their own code there.

DMS (Data Management Software) allows systems to easily take advantage of the advanced architecture of the simultaneous read/write product line by allowing removal of EEPROM devices. DMS also allows the system software to be simplified, as it performs all functions necessary to modify data in file structures, as opposed to single-byte modifications. To write or update a particular piece of data (a phone number or configuration data, for example), the user only needs to state which piece of data is to be updated, and where the updated data is located in the system. This is an advantage compared to systems where user-written software must keep track of the old data location, status, logical to physical translation of the data onto the Flash memory device (or memory devices), and more. Using DMS, user-written software does not need to interface with the Flash memory directly. Instead, the user's software accesses the Flash memory by calling one of only six functions. AMD provides this software to simplify system design and software integration efforts.

The device offers complete compatibility with the **JEDEC single-power-supply Flash command set standard**. Commands are written to the command register using standard microprocessor write timings. Reading data out of the device is similar to reading from other Flash or EPROM devices.

The host system can detect whether a program or erase operation is complete by using the device **status bits:** RY/BY# pin, DQ7 (Data# Polling) and DQ6/DQ2 (toggle bits). After a program or erase cycle is completed, the device automatically returns to reading array data.

The **sector erase architecture** allows memory sectors to be erased and reprogrammed without affecting the data contents of other sectors. The device is fully erased when shipped from the factory.

Hardware data protection measures include a low V_{CC} detector that automatically inhibits write operations during power transitions. The **hardware sector protection** feature disables both program and erase operations in any combination of the sectors of memory. This is achieved in-system or via programming equipment.

The device offers two power-saving features. When addresses are stable for a specified amount of time, the device enters the **automatic sleep mode**. The system can also place the device into the **standby mode**. Power consumption is greatly reduced in both modes.

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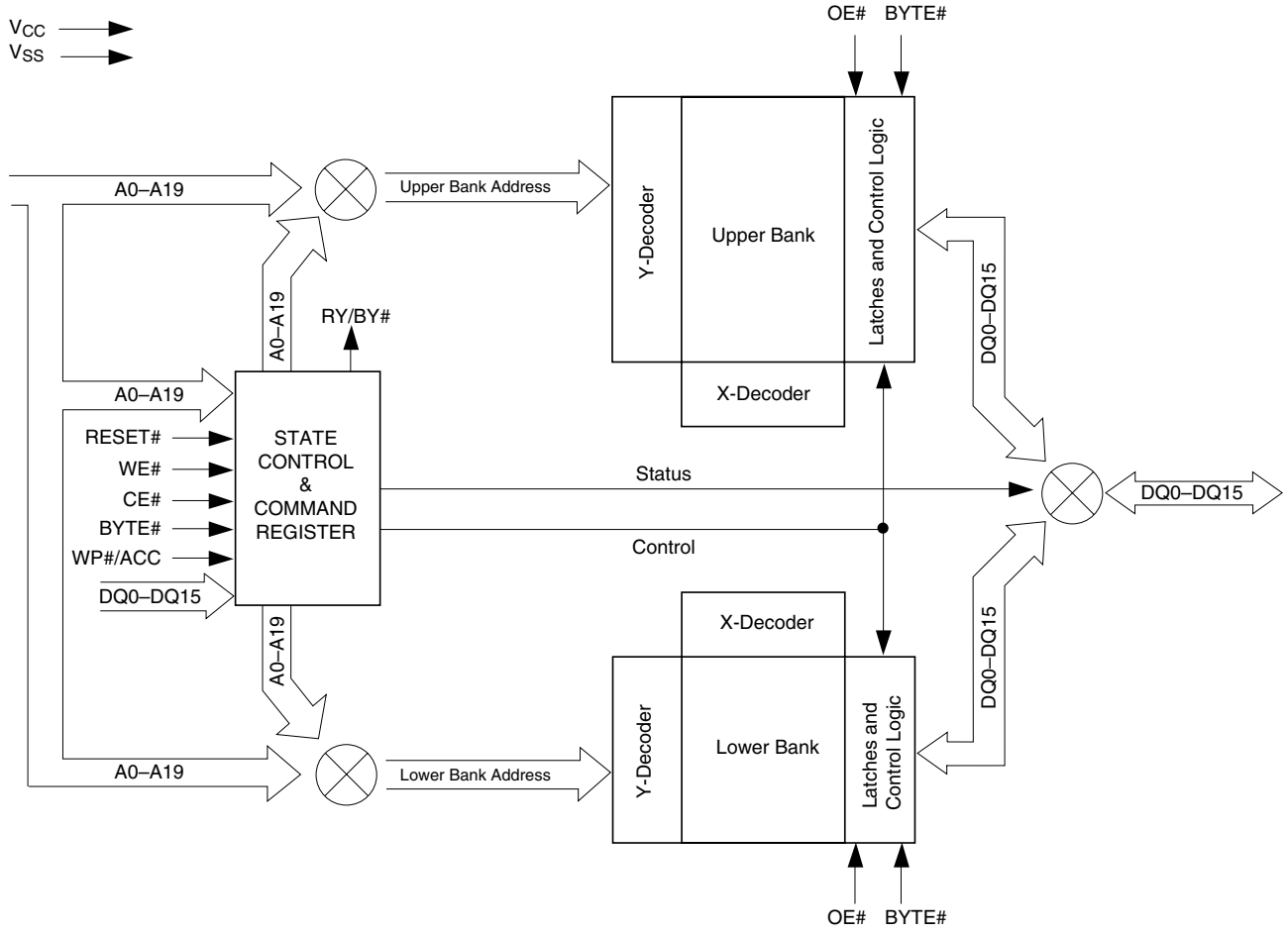
PRODUCT SELECTOR GUIDE

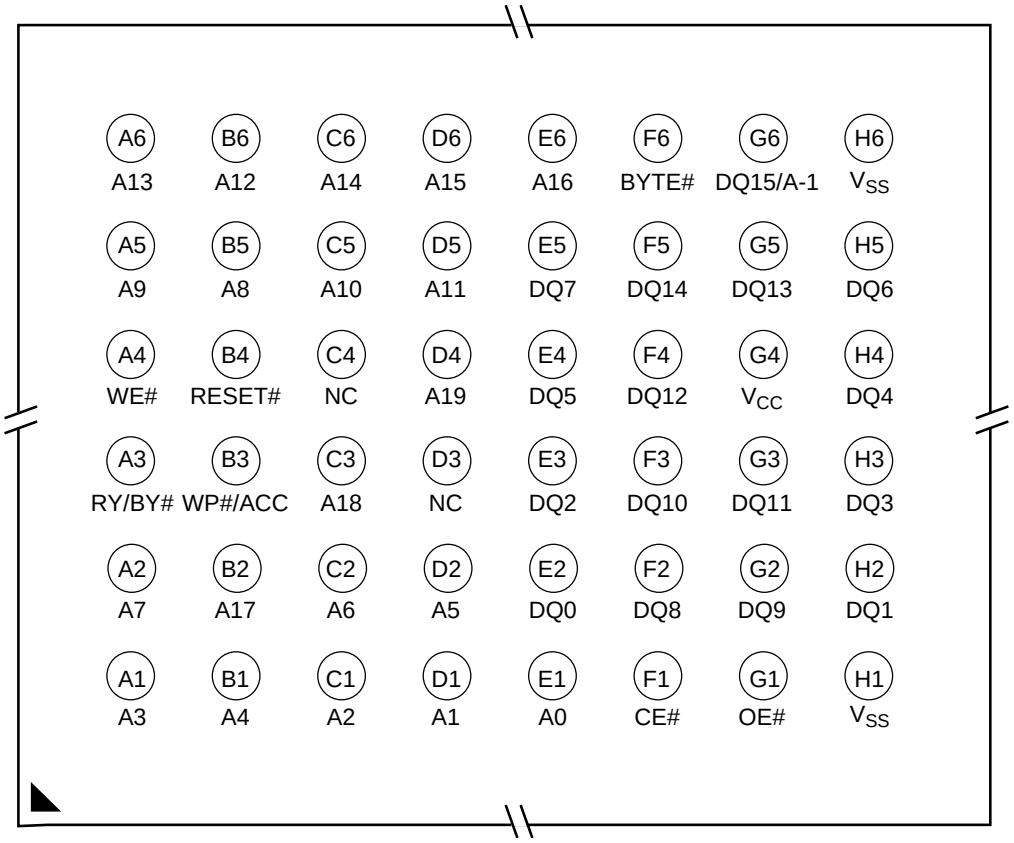
Part Number		Am29DS163D	
Speed Option	Standard Voltage Range: V_{CC} = 1.8–2.2 V	**100**	**120**
Max Access Time (ns)		100	120
CE# Access (ns)		100	120
OE# Access (ns)		35	50

BLOCK DIAGRAM



CONNECTION DIAGRAMS

48-Ball FBGA
Top View, Balls Facing Down


A6 B6 C6 D6 E6 F6 G6 H6
A13 A12 A14 A15 A16 BYTE# DQ15/A-1 VSS
A5 B5 C5 D5 E5 F5 G5 H5
A9 A8 A10 A11 DQ7 DQ14 DQ13 DQ6
A4 B4 C4 D4 E4 F4 G4 H4
WE# RESET# NC A19 DQ5 DQ12 VCC DQ4
A3 B3 C3 D3 E3 F3 G3 H3
RY/BY# WP#/ACC A18 NC DQ2 DQ10 DQ11 DQ3
A2 B2 C2 D2 E2 F2 G2 H2
A7 A17 A6 A5 DQ0 DQ8 DQ9 DQ1
A1 B1 C1 D1 E1 F1 G1 H1
A3 A4 A2 A1 A0 CE# OE# VSS

Special Handling Instructions for FBGA Package

Special handling is required for Flash Memory products in FBGA packages.

Flash memory devices in FBGA packages may be damaged if exposed to ultrasonic cleaning methods. The package and/or data integrity may be compromised if the package body is exposed to temperatures above 150°C for prolonged periods of time.

PIN DESCRIPTION

A0–A19 = 20 Addresses

DQ0–DQ14 = 15 Data Inputs/Outputs

DQ15/A-1 = DQ15 (Data Input/Output, word mode), A-1 (LSB Address Input, byte mode)

CE# = Chip Enable

OE# = Output Enable

WE# = Write Enable

WP#/ACC = Hardware Write Protect/ Acceleration Pin

RESET# = Hardware Reset Pin, Active Low

BYTE# = Selects 8-bit or 16-bit mode

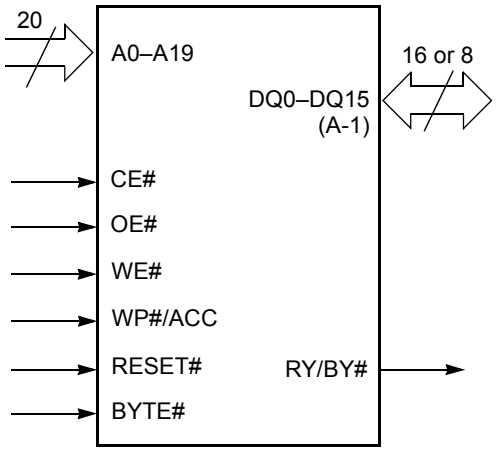
RY/BY# = Ready/Busy Output

V_{CC} = 1.8 volt-only single power supply (see Product Selector Guide for speed options and voltage supply tolerances)

V_{SS} = Device Ground

NC = Pin Not Connected Internally

LOGIC SYMBOL



ORDERING INFORMATION

Standard Products

AMD standard products are available in several packages and operating ranges. The order number (Valid Combination) is formed by a combination of the following:

Am29DS163D T 100 E I

OPTIONAL PROCESSING
Blank = Standard Processing
N = 16-byte ESN devices
(Contact an AMD representative for more information)

TEMPERATURE RANGE
I = Industrial (–40°C to +85°C)
E = Extended (–55°C to +125°C)
F = Industrial (-40°C to +85°C) with Pb-free Package
K = Extended (-55°C to +125°C) with Pb-free Package

PACKAGE TYPE
WA = 48-Ball Fine-Pitch Ball Grid Array (FBGA)
0.80 mm pitch, 6 x 8 mm package (FBA048)

SPEED OPTION
See Product Selector Guide and Valid Combinations

BOOT CODE SECTOR ARCHITECTURE
T = Top sector
B = Bottom sector

DEVICE NUMBER/DESCRIPTION
Am29DS163D
16Megabit (2 M x 8-Bit/1 M x 16-Bit) CMOS Flash Memory
1.8 Volt-only Read, Program, and Erase

Valid Combinations for FBGA Packages			
Order Number		**Package Marking**	
Am29DS163DT100, Am29DS163DB100	WAI, WAE, WAF, WAK	S163DT10V, S163DB10V	I, E, F, K
Am29DS163DT120, Am29DS163DB120		S163DT12V, S163DB12V	

Valid Combinations

Valid Combinations list configurations planned to be supported in volume for this device. Consult the local AMD sales office to confirm availability of specific valid combinations and to check on newly released combinations.

DEVICE BUS OPERATIONS

This section describes the requirements and use of the device bus operations, which are initiated through the internal command register. The command register itself does not occupy any addressable memory location. The register is a latch used to store the commands, along with the address and data information needed to execute the command. The contents of the register serve as inputs to the internal state machine. The state machine outputs dictate the function of the device. Table 1 lists the device bus operations, the inputs and control levels they require, and the resulting output. The following subsections describe each of these operations in further detail.

Table 1. Am29DS163D Device Bus Operations

Operation	CE#	OE#	WE#	RESET#	WP#/ACC	Addresses (Note 2)	DQ0–DQ7	DQ8–DQ15	
								BYTE# = V_{IH}	BYTE# = V_{IL}
Read	L	L	H	H	L/H	A_{IN}	D_{OUT}	D_{OUT}	DQ8–DQ14 = High-Z, DQ15 = A-1
Write	L	H	L	H	(Note 3)	A_{IN}	D_{IN}	D_{IN}	
Standby	$V_{CC} \pm 0.3$ V	X	X	$V_{CC} \pm 0.3$ V	H	X	High-Z	High-Z	High-Z
Output Disable	L	H	H	H	L/H	X	High-Z	High-Z	High-Z
Reset	X	X	X	L	L/H	X	High-Z	High-Z	High-Z
Sector Protect (Note 2)	L	H	L	V_{ID}	L/H	SA, A6 = L, A1 = H, A0 = L	D_{IN}	X	X
Sector Unprotect (Note 2)	L	H	L	V_{ID}	(Note 3)	SA, A6 = H, A1 = H, A0 = L	D_{IN}	X	X
Temporary Sector Unprotect	X	X	X	V_{ID}	(Note 3)	A_{IN}	D_{IN}	D_{IN}	High-Z

Legend: *L = Logic Low = V_{IL}, H = Logic High = V_{IH}, V_{ID} = 9.0–11.0 V, V_{HH} = 9.0 ± 0.5 V, X = Don't Care, SA = Sector Address, A_{IN} = Address In, D_{IN} = Data In, D_{OUT} = Data Out*

Notes:

1. *Addresses are A19:A0 in word mode (BYTE# = V_{IH}), A19:A-1 in byte mode (BYTE# = V_{IL}).*
2. *The sector protect and sector unprotect functions may also be implemented via programming equipment. See "Sector/Sector Block Protection and Unprotection" on page 16.*
3. *If WP#/ACC = V_{IL}, the two outermost boot sectors remain protected. If WP#/ACC = V_{IH}, the two outermost boot sector protection depends on whether they were last protected or unprotected using the method described in "Sector/Sector Block Protection and Unprotection" on page 16. If WP#/ACC = V_{HH}, all sectors are unprotected.*

Word/Byte Configuration

The BYTE# pin controls whether the device data I/O pins operate in the byte or word configuration. If the BYTE# pin is set at logic '1', the device is in word configuration, DQ0–DQ15 are active and controlled by CE# and OE#.

If the BYTE# pin is set at logic '0', the device is in byte configuration, and only data I/O pins DQ0–DQ7 are active and controlled by CE# and OE#. The data I/O pins DQ8–DQ14 are tri-stated, and the DQ15 pin is used as an input for the LSB (A-1) address function.

Requirements for Reading Array Data

To read array data from the outputs, the system must drive the CE# and OE# pins to V_{IL}. CE# is the power control and selects the device. OE# is the output control and gates array data to the output pins. WE# should remain at V_{IH}. The BYTE# pin determines whether the device outputs array data in words or bytes.

The internal state machine is set for reading array data upon device power-up, or after a hardware reset. This ensures that no spurious alteration of the memory content occurs during the power transition. No command is necessary in this mode to obtain array data. Standard microprocessor read cycles that assert valid

addresses on the device address inputs produce valid data on the device data outputs. Each bank remains enabled for read access until the command register contents are altered.

See "Requirements for Reading Array Data" on page 10 for more information. Refer to the Table on page 36 for timing specifications and to Figure 13, on page 36 for the timing diagram. I_{CC1} in the DC Characteristics table represents the active current specification for reading array data.

Writing Commands/Command Sequences

To write a command or command sequence (which includes programming data to the device and erasing sectors of memory), the system must drive WE# and CE# to V_{IL}, and OE# to V_{IH}.

For program operations, the BYTE# pin determines whether the device accepts program data in bytes or words. Refer to "Word/Byte Configuration" on page 10 for more information.

The device features an **Unlock Bypass** mode to facilitate faster programming. Once a bank enters the Unlock Bypass mode, only two write cycles are required to program a word or byte, instead of four. The "Word/Byte Configuration" section contains details on programming data to the device using both standard and Unlock Bypass command sequences.

An erase operation can erase one sector, multiple sectors, or the entire device. Table 3 on page 13 to Table 6 on page 14 indicate the address space that each sector occupies. The device address space is divided into two banks: Bank 1 contains the boot/parameter sectors, and Bank 2 contains the larger, code sectors of uniform size. A "bank address" is the address bits required to uniquely select a bank. Similarly, a "sector address" is the address bits required to uniquely select a sector.

I_{CC2} in the DC Characteristics table represents the active current specification for the write mode. The "AC Characteristics" on page 36 section contains timing specification tables and timing diagrams for write operations.

Accelerated Program Operation

The device offers accelerated program operations through the ACC function. This is one of two functions provided by the WP#/ACC pin. This function is primarily intended to allow faster manufacturing throughput at the factory.

If the system asserts V_{HH} on this pin, the device automatically enters the aforementioned Unlock Bypass mode, temporarily unprotects any protected sectors, and uses the higher voltage on the pin to reduce the time required for program operations. The system would use a two-cycle program command sequence as required by the Unlock Bypass mode. Removing V_{HH} from the WP#/ACC pin returns the device to normal operation. Note that the WP#/ACC pin must not be at V_{HH} for operations other than accelerated programming, or device damage may result. In addition, the WP#/ACC pin must not be left floating or unconnected; inconsistent behavior of the device may result.

Autoselect Functions

If the system writes the autoselect command sequence, the device enters the autoselect mode. The system can then read autoselect codes from the internal register (which is separate from the memory array) on DQ7–DQ0. Standard read cycle timings apply in this mode. Refer to "Autoselect Mode" on page 15 and "Autoselect Command Sequence" on page 23 for more information.

Simultaneous Read/Write Operations with Zero Latency

This device is capable of reading data from one bank of memory while programming or erasing in the other bank of memory. An erase operation may also be suspended to read from or program to another location within the same bank (except the sector being erased). Figure 20, on page 42 shows how read and write cycles may be initiated for simultaneous operation with zero latency. I_{CC6} and I_{CC7} in the DC Characteristics table represent the current specifications for read-while-program and read-while-erase, respectively.

Standby Mode

When the system is not reading or writing to the device, it can place the device in the standby mode. In this mode, current consumption is greatly reduced, and the outputs are placed in the high impedance state, independent of the OE# input.

The device enters the CMOS standby mode when the CE# and RESET# pins are both held at $V_{CC} \pm 0.3$ V. (Note that this is a more restricted voltage range than V_{IH}.) If CE# and RESET# are held at V_{IH}, but not within $V_{CC} \pm 0.3$ V, the device is in the standby mode, but the standby current is greater. The device requires standard access time (t_{CE}) for read access when the device is in either of these standby modes, before it is ready to read data.

If the device is deselected during erasure or programming, the device draws active current until the operation is completed.

I_{CC3} in the DC Characteristics table represents the standby current specification.

Automatic Sleep Mode

The automatic sleep mode minimizes Flash device energy consumption. The device automatically enables this mode when addresses remain stable for t_{ACC} + 30 ns. The automatic sleep mode is independent of the CE#, WE#, and OE# control signals. Standard address access timings provide new data when addresses are changed. While in sleep mode, output data is latched and always available to the system. I_{CC4} in the "DC Characteristics" on page 33 represents the automatic sleep mode current specification.

RESET#: Hardware Reset Pin

The RESET# pin provides a hardware method of resetting the device to reading array data. When the RESET# pin is driven low for at least a period of t_{RP}, the device immediately terminates any operation in progress, tristates all output pins, and ignores all read/write commands for the duration of the RESET# pulse. The device also resets the internal state machine to reading array data. The operation that was interrupted should be reinitiated once the device is ready to accept another command sequence, to ensure data integrity.

Current is reduced for the duration of the RESET# pulse. When RESET# is held at V_{SS}±0.3 V, the device draws CMOS standby current (I_{CC4}). If RESET# is held at V_{IL} but not within V_{SS}±0.3 V, the standby current is greater.

The RESET# pin may be tied to the system reset circuitry. A system reset would thus also reset the Flash memory, enabling the system to read the boot-up firmware from the Flash memory.

If RESET# is asserted during a program or erase operation, the RY/BY# pin remains a "0" (busy) until the internal reset operation is complete, which requires a time of t_{READY} (during Embedded Algorithms). The system can thus monitor RY/BY# to determine whether the reset operation is complete. If RESET# is asserted when a program or erase operation is not executing (RY/BY# pin is "1"), the reset operation is completed within a time of t_{READY} (not during Embedded Algorithms). The system can read data t_{RH} after the RESET# pin returns to V_{IH}.

Refer to "AC Characteristics" on page 36 for RESET# parameters and to Figure 14, on page 37 for the timing diagram.

Output Disable Mode

When the OE# input is at V_{IH}, output from the device is disabled. The output pins are placed in the high impedance state.

Table 2. Am29DS163D Device Bank Divisions

Device Part Number	Bank 1		Bank 2	
	Megabits	Sector Sizes	Megabits	Sector Sizes
Am29DS163D	4 Mbit	Eight 8 Kbyte/4 Kword, seven 64 Kbyte/32 Kword	12 Mbit	Twenty-four 64 Kbyte/32 Kword

Table 3. Top Boot Sector Addresses (Am29DS16xDT)

Am29DS163DT	Sector	Sector Address A19–A12	Sector Size (Kbytes/Kwords)	(x8) Address Range	(x16) Address Ranges
Bank 2	SA0	00000xxx	64/32	000000h-00FFFFh	00000h–07FFFh
	SA1	00001xxx	64/32	010000h-01FFFFh	08000h–0FFFFh
	SA2	00010xxx	64/32	020000h-02FFFFh	10000h–17FFFh
	SA3	00011xxx	64/32	030000h-03FFFFh	18000h–1FFFFh
	SA4	00100xxx	64/32	040000h-04FFFFh	20000h–27FFFh
	SA5	00101xxx	64/32	050000h-05FFFFh	28000h–2FFFFh
	SA6	00110xxx	64/32	060000h-06FFFFh	30000h–37FFFh
	SA7	00111xxx	64/32	070000h-07FFFFh	38000h–3FFFFh
	SA8	01000xxx	64/32	080000h-08FFFFh	40000h–47FFFh
	SA9	01001xxx	64/32	090000h-09FFFFh	48000h–4FFFFh
	SA10	01010xxx	64/32	0A0000h-0AFFFFh	50000h–57FFFh
	SA11	01011xxx	64/32	0B0000h-0BFFFFh	58000h–5FFFFh
	SA12	01100xxx	64/32	0C0000h-0CFFFFh	60000h–67FFFh
	SA13	01101xxx	64/32	0D0000h-0DFFFFh	68000h–6FFFFh
	SA14	01110xxx	64/32	0E0000h-0EFFFFh	70000h–77FFFh
	SA15	01111xxx	64/32	0F0000h-0FFFFFh	78000h–7FFFFh
	SA16	10000xxx	64/32	100000h-10FFFFh	80000h–87FFFh
	SA17	10001xxx	64/32	110000h-11FFFFh	88000h–8FFFFh
	SA18	10010xxx	64/32	120000h-12FFFFh	90000h–97FFFh
	SA19	10011xxx	64/32	130000h-13FFFFh	98000h–9FFFFh
	SA20	10100xxx	64/32	140000h-14FFFFh	A0000h–A7FFFh
	SA21	10101xxx	64/32	150000h-15FFFFh	A8000h–AFFFFh
	SA22	10110xxx	64/32	160000h-16FFFFh	B0000h–B7FFFh
	SA23	10111xxx	64/32	170000h-17FFFFh	B8000h–BFFFFh
Bank 1	SA24	11000xxx	64/32	180000h-18FFFFh	C0000h–C7FFFh
	SA25	11001xxx	64/32	190000h-19FFFFh	C8000h–CFFFFh
	SA26	11010xxx	64/32	1A0000h-1AFFFFh	D0000h–D7FFFh
	SA27	11011xxx	64/32	1B0000h-1BFFFFh	D8000h–DFFFFh
	SA28	11100xxx	64/32	1C0000h-1CFFFFh	E0000h–E7FFFh
	SA29	11101xxx	64/32	1D0000h-1DFFFFh	E8000h–EFFFFh
	SA30	11110xxx	64/32	1E0000h-1EFFFFh	F0000h–F7FFFh
	SA31	11111000	8/4	1F0000h-1F1FFFh	F8000h–F8FFFh
	SA32	11111001	8/4	1F2000h-1F3FFFh	F9000h–F9FFFh
	SA33	11111010	8/4	1F4000h-1F5FFFh	FA000h–FAFFFh
	SA34	11111011	8/4	1F6000h-1F7FFFh	FB000h–FBFFFh
	SA35	11111100	8/4	1F8000h-1F9FFFh	FC000h–FCFFFh
	SA36	11111101	8/4	1FA000h-1FBFFFh	FD000h–FDFFFh
	SA37	11111110	8/4	1FC000h-1FDFFFh	FE000h–FEFFFh
	SA38	11111111	8/4	1FE000h-1FFFFFh	FF000h–FFFFFh

Note: *The address range is A19:A-1 in byte mode (BYTE#=V_{IL}) or A19:A0 in word mode (BYTE#=V_{IH}). The bank address bits are A19 and A18 for Am29DS163DT.*

Table 4. SecSi Sector Addresses for Top Boot Devices

SecSi Sector	Sector Address A19–A12	Size	(x8) Address Range	(x16) Address Range
Entire Sector	11111xxx	64 Kbytes/32 Kwords	1F0000h-1FFFFFh	F8000h–FFFFFh
Factory Programmed ESN	11111xxx	16 bytes/8 words	1F0000h-1F000Fh	F8000h–F8007h

Table 5. Bottom Boot Sector Addresses (Am29DS16xDB)

Am29DS163DB	Sector	Sector Address A19–A12	Sector Size (Kbytes/Kwords)	(x8) Address Range	(x16) Address Range
Bank 1	SA0	00000000	8/4	000000h-001FFFh	00000h-00FFFh
	SA1	00000001	8/4	002000h-003FFFh	01000h-01FFFh
	SA2	00000010	8/4	004000h-005FFFh	02000h-02FFFh
	SA3	00000011	8/4	006000h-007FFFh	03000h-03FFFh
	SA4	00000100	8/4	008000h-009FFFh	04000h-04FFFh
	SA5	00000101	8/4	00A000h-00BFFFh	05000h-05FFFh
	SA6	00000110	8/4	00C000h-00DFFFh	06000h-06FFFh
	SA7	00000111	8/4	00E000h-00FFFFh	07000h-07FFFh
	SA8	00001XXX	64/32	010000h-01FFFFh	08000h-0FFFFh
	SA9	00010XXX	64/32	020000h-02FFFFh	10000h-17FFFh
	SA10	00011XXX	64/32	030000h-03FFFFh	18000h-1FFFFh
	SA11	00100XXX	64/32	040000h-04FFFFh	20000h-27FFFh
	SA12	00101XXX	64/32	050000h-05FFFFh	28000h-2FFFFh
	SA13	00110XXX	64/32	060000h-06FFFFh	30000h-37FFFh
	SA14	00111XXX	64/32	070000h-07FFFFh	38000h-3FFFFh
Bank 2	SA15	01000XXX	64/32	080000h-08FFFFh	40000h-47FFFh
	SA16	01001XXX	64/32	090000h-09FFFFh	48000h-4FFFFh
	SA17	01010XXX	64/32	0A0000h-0AFFFFh	50000h-57FFFh
	SA18	01011XXX	64/32	0B0000h-0BFFFFh	58000h-5FFFFh
	SA19	01100XXX	64/32	0C0000h-0CFFFFh	60000h-67FFFh
	SA20	01101XXX	64/32	0D0000h-0DFFFFh	68000h-6FFFFh
	SA21	01110XXX	64/32	0E0000h-0EFFFFh	70000h-77FFFh
	SA22	01111XXX	64/32	0F0000h-0FFFFFh	78000h-7FFFFh
	SA23	10000XXX	64/32	100000h-10FFFFh	80000h-87FFFh
	SA24	10001XXX	64/32	110000h-11FFFFh	88000h-8FFFFh
	SA25	10010XXX	64/32	120000h-12FFFFh	90000h-97FFFh
	SA26	10011XXX	64/32	130000h-13FFFFh	98000h-9FFFFh
	SA27	10100XXX	64/32	140000h-14FFFFh	A0000h-A7FFFh
	SA28	10101XXX	64/32	150000h-15FFFFh	A8000h-AFFFFh
	SA29	10110XXX	64/32	160000h-16FFFFh	B0000h-B7FFFh
	SA30	10111XXX	64/32	170000h-17FFFFh	B8000h-BFFFFh
	SA31	11000XXX	64/32	180000h-18FFFFh	C0000h-C7FFFh
	SA32	11001XXX	64/32	190000h-19FFFFh	C8000h-CFFFFh
	SA33	11010XXX	64/32	1A0000h-1AFFFFh	D0000h-D7FFFh
	SA34	11011XXX	64/32	1B0000h-1BFFFFh	D8000h-DFFFFh
	SA35	11100XXX	64/32	1C0000h-1CFFFFh	E0000h-E7FFFh
	SA36	11101XXX	64/32	1D0000h-1DFFFFh	E8000h-EFFFFh
	SA37	11110XXX	64/32	1E0000h-1EFFFFh	F0000h-F7FFFh
	SA38	11111XXX	64/32	1F0000h-1FFFFFh	F8000h-FFFFFh

Note: *The address range is A19:A-1 in byte mode (BYTE#=V_{IL}) or A19:A0 in word mode (BYTE#=V_{IH}). The bank address bits are A19 and A18 for Am29DS163DB.*

Table 6. SecSi Sector Addresses for Bottom Boot Devices

SecSi Sector	Sector Address A19–A12	Size	(x8) Address Range	(x16) Address Range
Entire Sector	00000XXX	64 Kbytes/32 Kwords	000000h-00FFFFh	00000h-07FFFh
Factory Programmed ESN	00000XXX	16 bytes/8 words	000000h-00000Fh	00000h–00007h

Autoselect Mode

The autoselect mode provides manufacturer and device identification, and sector protection verification, through identifier codes output on DQ7–DQ0. This mode is primarily intended for programming equipment to automatically match a device to be programmed with its corresponding programming algorithm. However, the autoselect codes can also be accessed in-system through the command register.

When using programming equipment, the autoselect mode requires V_{ID} (9.0 V to 11.0 V) on address pin A9. Address pins A6, A1, and A0 must be as shown in Table 7. In addition, when verifying sector protection, the sector address must appear on the appropriate highest order address bits (see Tables 3–6). Table 7 shows the remaining address bits that are don't care. When all necessary bits are set as required, the programming equipment may then read the corresponding identifier code on DQ7–DQ0.

To access the autoselect codes in-system, the host system can issue the autoselect command via the command register, as shown in Table 14. This method does not require V_{ID}. Refer to the Autoselect Command Sequence section for more information.

Table 7. Am29DS163D Autoselect Codes (High Voltage Method)

Description	CE#	OE#	WE#	A19 to A12	A11 to A10	A9	A8 to A7	A6	A5 to A2	A1	A0	DQ8 to DQ15		DQ7 to DQ0
												BYTE# = V_{IH}	BYTE# = V_{IL}	
Manufacturer ID: AMD	L	L	H	BA	X	V_{ID}	X	L	X	L	L	X	X	01h
Device ID: Am29DS163D	L	L	H	BA	X	V_{ID}	X	L	X	L	H	22h	X	95h (T), 96h (B)
Sector Protection Verification	L	L	H	SA	X	V_{ID}	X	L	X	H	L	X	X	01h (protected), 00h (unprotected)
SecSi Sector Indicator Bit (DQ7)	L	L	H	BA	X	V_{ID}	X	L	X	H	H	X	X	85h (factory locked), 05h (not factory locked)

Legend: *T = Top Boot Block, B = Bottom Boot Block, L = Logic Low = V_{IL}, H = Logic High = V_{IH}, BA = Bank Address, SA = Sector Address, X = Don't care.*

Sector/Sector Block Protection and Unprotection

(Note: For the following discussion, the term “sector” applies to both sectors and sector blocks. A sector block consists of two or more adjacent sectors that are protected or unprotected at the same time (see Tables 8 and 9).

Table 8. Top Boot Sector/Sector Block Addresses for Protection/Unprotection

Sector / Sector Block	A19–A12	Sector / Sector Block Size
SA0	00000XXX	64 Kbytes
SA1-SA3	00001XXX, 00010XXX, 00011XXX	192 (3x64) Kbytes
SA4-SA7	001XXXXX	256 (4x64) Kbytes
SA8-SA11	010XXXXX	256 (4x64) Kbytes
SA12-SA15	011XXXXX	256 (4x64) Kbytes
SA16-SA19	100XXXXX	256 (4x64) Kbytes
SA20-SA23	101XXXXX	256 (4x64) Kbytes
SA24-SA27	110XXXXX	256 (4x64) Kbytes
SA28-SA30	11100XXX, 11101XXX, 11110XXX	192 (3x64) Kbytes
SA31	11111000	8 Kbytes
SA32	11111001	8 Kbytes
SA33	11111010	8 Kbytes
SA34	11111011	8 Kbytes
SA35	11111100	8 Kbytes
SA36	11111101	8 Kbytes
SA37	11111110	8 Kbytes
SA38	11111111	8 Kbytes

Table 9. Bottom Boot Sector/Sector Block Addresses for Protection/Unprotection

Sector / Sector Block	A19–A12	Sector / Sector Block Size
SA38	11111XXX	64 Kbytes
SA37-SA35	11110XXX, 11101XXX, 11100XXX	192 (3x64) Kbytes
SA34-SA31	110XXXXX	256 (4x64) Kbytes
SA30-SA27	101XXXXX	256 (4x64) Kbytes
SA26-SA23	100XXXXX	256 (4x64) Kbytes
SA22-SA19	011XXXXX	256 (4x64) Kbytes
SA18-SA15	010XXXXX	256 (4x64) Kbytes
SA14-SA11	001XXXXX	256 (4x64) Kbytes
SA10-SA8	00001XXX, 00010XXX, 00011XXX	192 (3x64) Kbytes
SA7	00000111	8 Kbytes
SA6	00000110	8 Kbytes
SA5	00000101	8 Kbytes
SA4	00000100	8 Kbytes
SA3	00000011	8 Kbytes
SA2	00000010	8 Kbytes
SA1	00000001	8 Kbytes
SA0	00000000	8 Kbytes

The hardware sector protection feature disables both program and erase operations in any sector. The hardware sector unprotection feature re-enables both program and erase operations in previously protected sectors. Sector protection and unprotection can be implemented via two methods.

The primary method requires V_{ID} on the RESET# pin only, and can be implemented either in-system or via programming equipment. Figure 2 shows the algorithms and Figure 25 shows the timing diagram. This method uses standard microprocessor bus cycle timing. For sector unprotect, all unprotected sectors must first be protected prior to the first sector unprotect write cycle.

The alternate method intended only for programming equipment requires V_{ID} on address pin A9 and OE#. This method is compatible with programmer routines written for earlier 1.8 volt-only AMD flash devices. Contact an AMD representative for further details.

The device is shipped with all sectors unprotected. AMD offers the option of programming and protecting sectors at its factory prior to shipping the device through AMD's ExpressFlash™ Service. Contact an AMD representative for details.

It is possible to determine whether a sector is protected or unprotected. See the Autoselect Mode section for details.

Write Protect (WP#)

The Write Protect function provides a hardware method of protecting certain boot sectors without using V_{ID}. This function is one of two provided by the WP#/ACC pin.

If the system asserts V_{IL} on the WP#/ACC pin, the device disables program and erase functions in the two "outermost" 8 Kbyte boot sectors independently of whether those sectors were protected or unprotected using the method described in "Sector/Sector Block Protection and Unprotection". The two outermost 8 Kbyte boot sectors are the two sectors containing the lowest addresses in a bottom-boot-configured device, or the two sectors containing the highest addresses in a top-boot-configured device.

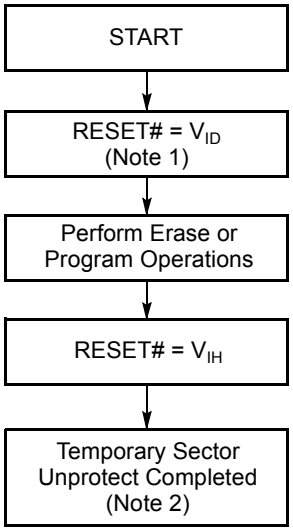
If the system asserts V_{IH} on the WP#/ACC pin, the device reverts to whether the two outermost 8 Kbyte boot sectors were last set to be protected or unprotected. That is, sector protection or unprotection for these two sectors depends on whether they were last protected or unprotected using the method described in "Sector/Sector Block Protection and Unprotection".

Note that the WP#/ACC pin must not be left floating or unconnected; inconsistent behavior of the device may result.

Temporary Sector/Sector Block Unprotect

(Note: For the following discussion, the term "sector" applies to both sectors and sector blocks. A sector block consists of two or more adjacent sectors that are protected or unprotected at the same time (see Tables 8 and 9).

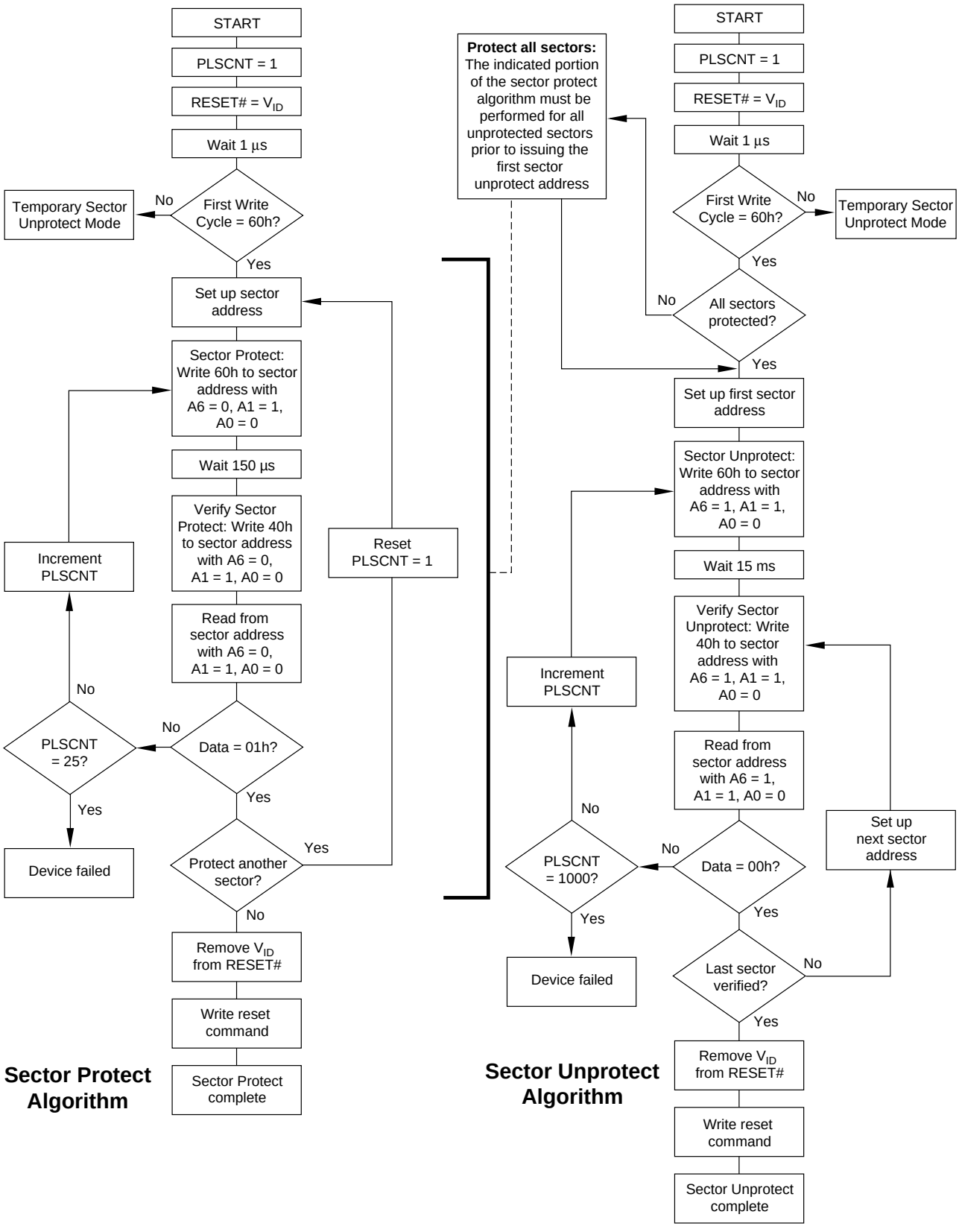
This feature allows temporary unprotection of previously protected sectors to change data in-system. The Sector Unprotect mode is activated by setting the RESET# pin to V_{ID} (9.0 – 11.0 V). During this mode, formerly protected sectors can be programmed or erased by selecting the sector addresses. Once V_{ID} is removed from the RESET# pin, all the previously protected sectors are protected again. Figure 1 shows the algorithm, and Figure 24 shows the timing diagrams, for this feature.



Notes:

1. *All protected sectors unprotected (If WP#/ACC = V_{IL}, outermost boot sectors will remain protected).*
2. *All previously protected sectors are protected once again.*

Figure 1. Temporary Sector Unprotect Operation


START
PLSCNT = 1
RESET# = V_{ID}
Wait 1 µs
First Write Cycle = 60h?
No
Temporary Sector Unprotect Mode
Yes
Set up sector address
Sector Protect: Write 60h to sector address with A6 = 0, A1 = 1, A0 = 0
Wait 150 µs
Verify Sector Protect: Write 40h to sector address with A6 = 0, A1 = 1, A0 = 0
Read from sector address with A6 = 0, A1 = 1, A0 = 0
Data = 01h?
No
Yes
PLSCNT = 25?
No
Yes
Increment PLSCNT
Device failed
Protect another sector?
Yes
No
Reset PLSCNT = 1
Remove V_{ID} from RESET#
Write reset command
Sector Protect complete
Sector Protect Algorithm
Protect all sectors: The indicated portion of the sector protect algorithm must be performed for all unprotected sectors prior to issuing the first sector unprotect address
START
PLSCNT = 1
RESET# = V_{ID}
Wait 1 µs
First Write Cycle = 60h?
No
Temporary Sector Unprotect Mode
Yes
All sectors protected?
No
Yes
Set up first sector address
Sector Unprotect: Write 60h to sector address with A6 = 1, A1 = 1, A0 = 0
Wait 15 ms
Verify Sector Unprotect: Write 40h to sector address with A6 = 1, A1 = 1, A0 = 0
Read from sector address with A6 = 1, A1 = 1, A0 = 0
Data = 00h?
No
Yes
PLSCNT = 1000?
No
Yes
Increment PLSCNT
Device failed
Set up next sector address
Last sector verified?
No
Yes
Remove V_{ID} from RESET#
Write reset command
Sector Unprotect complete
Sector Unprotect Algorithm

Note: The term "sector" in the figure applies to both sectors and sector blocks.

Figure 2. In-System Sector/Sector Block Protect and Unprotect Algorithms

SecSi (Secured Silicon) Sector Flash Memory Region

The SecSi (Secured Silicon) Sector feature provides an additional 64Kbyte Flash memory region that enables permanent part identification through an Electronic Serial Number (ESN). An SecSi Sector Indicator Bit indicates whether or not the SecSi Sector is locked when shipped from the factory. This bit is permanently set at the factory and cannot be changed, which prevents cloning of a factory locked part. This ensures the security of the ESN once the product is shipped to the field.

AMD offers the device with the SecSi Sector either factory locked or customer lockable. The factory-locked version is always protected when shipped from the factory, and the SecSi Sector Indicator Bit is permanently set to a "1." The customer-lockable version is shipped with the unprotected, allowing customers to utilize the that sector in any manner they choose. In the customer-lockable version, the SecSi Sector Indicator Bit is permanently set to a "0." Thus, the SecSi Sector Indicator Bit prevents customer-lockable devices from being used to replace devices that are factory locked.

The system accesses the SecSi Sector through a command sequence (see "Enter SecSi Sector/Exit SecSi Sector Command Sequence" on page 24). After the system writes the Enter SecSi Sector command sequence, it may read the SecSi Sector by using the addresses normally occupied by the boot sectors. This mode of operation continues until the system issues the Exit SecSi Sector command sequence, or until power is removed from the device. On power-up, or following a hardware reset, the device reverts to sending commands to the boot sectors.

The following restrictions apply to using the SecSi Sector: Once the device enters the SecSi Sector, any attempt to initiate program or erase operations in the array is ignored until the device exits the SecSi Sector. Conversely, when a program or erase operation in the array is in progress, the device ignores any attempt to enter the SecSi Sector until programming or erasing is complete.

Factory Locked: SecSi Sector Programmed and Protected at the Factory

In a factory locked device, the SecSi Sector is protected when the device is shipped from the factory. The SecSi Sector cannot be modified in any way. The device is available preprogrammed with one of the following:

- A random, secure ESN only
- Customer code through the ExpressFlash service
- Both a random, secure ESN and customer code through the ExpressFlash service.

In devices that have an ESN, a Bottom Boot device has the 16-byte ESN at addresses 00000h–00007h in word mode (or 000000h–00000Fh in byte mode). In the Top Boot device the starting address of the ESN is at addresses F8000h–F8007h in word mode (or 1F0000h–1F000Fh in byte mode).

Customers may opt to have their code programmed by AMD through the AMD ExpressFlash service. AMD programs the customer's code, with or without the random ESN. The devices are then shipped from AMD's factory with the permanently locked. Contact an AMD representative for details on using AMD's ExpressFlash service.

Customer Lockable: SecSi Sector NOT Programmed or Protected at the Factory

If the security feature is not required, the SecSi Sector can be treated as an additional Flash memory space, expanding the size of the available Flash array by 64 Kbytes. The SecSi Sector can be read, programmed, and erased as often as required. The SecSi Sector area can be protected using one of the following procedures:

- Write the three-cycle Enter SecSi Sector Region command sequence, and then follow the in-system sector protect algorithm as shown in Figure 2, except that *RESET# may be at either V_{IH} or V_{ID}*. This allows in-system protection of the without raising any device pin to a high voltage. Note that this method is only applicable to the SecSi Sector.
- Write the three-cycle Enter SecSi Sector Region command sequence, and then use the alternate method of sector protection described in "Sector/Sector Block Protection and Unprotection" on page 16.

Once the SecSi Sector is locked and verified, the system must write the Exit SecSi Sector Region command sequence to return to reading and writing the remainder of the array.

The SecSi Sector protection must be used with caution since, once protected, there is no procedure available for unprotecting the SecSi Sector area and none of the bits in the SecSi Sector memory space can be modified in any way. Note also that the multiple program and erase capability of the customer lockable version of this device may be subject to change on future device revisions.

Hardware Data Protection

The command sequence requirement of unlock cycles for programming or erasing provides data protection against inadvertent writes (refer to Table 14 on page 27 for command definitions). In addition, the following hardware data protection measures prevent accidental erasure or programming, which might otherwise be caused by spurious system level signals

during V_{CC} power-up and power-down transitions, or from system noise.

Low V_{CC} Write Inhibit

When V_{CC} is less than V_{LKO}, the device does not accept any write cycles. This protects data during V_{CC} power-up and power-down. The command register and all internal program/erase circuits are disabled, and the device resets to reading array data. Subsequent writes are ignored until V_{CC} is greater than V_{LKO}. The system must provide the proper signals to the control pins to prevent unintentional writes when V_{CC} is greater than V_{LKO}.

Write Pulse “Glitch” Protection

Noise pulses of less than 5 ns (typical) on OE#, CE# or WE# do not initiate a write cycle.

Logical Inhibit

Write cycles are inhibited by holding any one of OE# = V_{IL}, CE# = V_{IH} or WE# = V_{IH}. To initiate a write cycle, CE# and WE# must be a logical zero while OE# is a logical one.

Power-Up Write Inhibit

If WE# = CE# = V_{IL} and OE# = V_{IH} during power up, the device does not accept commands on the rising edge of WE#. The internal state machine is automatically reset to reading array data on power-up.

COMMON FLASH MEMORY INTERFACE (CFI)

The Common Flash Interface (CFI) specification outlines device and host system software interrogation handshake, which allows specific vendor-specified software algorithms to be used for entire families of devices. Software support can then be device-independent, JEDEC ID-independent, and forward- and backward-compatible for the specified flash device families. Flash vendors can standardize their existing interfaces for long-term compatibility.

This device enters the CFI Query mode when the system writes the CFI Query command, 98h, to address 55h in word mode (or address AAh in byte mode), any time the device is ready to read array data. The system can read CFI information at the addresses given in Table 10 on page 20 to Table 13 on page 22. To terminate reading CFI data, the system must write the reset command.

The system can also write the CFI query command when the device is in the autoselect mode. The device enters the CFI query mode, and the system can read CFI data at the addresses given in Table 10 on page 20 to Table 13 on page 22. The system must write the reset command to return the device to the autoselect mode.

For further information, please refer to the CFI Specification and CFI Publication 100, available via the World Wide Web at http://www.amd.com/products/nvd/overview/cfi.html. Alternatively, contact an AMD representative for copies of these documents.

Table 10. CFI Query Identification String

Addresses (Word Mode)	Addresses (Byte Mode)	Data	Description
10h 11h 12h	20h 22h 24h	0051h 0052h 0059h	Query Unique ASCII string “QRY”
13h 14h	26h 28h	0002h 0000h	Primary OEM Command Set
15h 16h	2Ah 2Ch	0040h 0000h	Address for Primary Extended Table
17h 18h	2Eh 30h	0000h 0000h	Alternate OEM Command Set (00h = none exists)
19h 1Ah	32h 34h	0000h 0000h	Address for Alternate OEM Extended Table (00h = none exists)

Table 11. System Interface String

Addresses (Word Mode)	Addresses (Byte Mode)	Data	Description
1Bh	36h	0018h	V_{CC} Min. (write/erase) D7–D4: volt, D3–D0: 100 millivolt
1Ch	38h	0022h	V_{CC} Max. (write/erase) D7–D4: volt, D3–D0: 100 millivolt
1Dh	3Ah	0000h	V_{PP} Min. voltage (00h = no V_{PP} pin present)
1Eh	3Ch	0000h	V_{PP} Max. voltage (00h = no V_{PP} pin present)
1Fh	3Eh	0004h	Typical timeout per single byte/word write 2^N µs
20h	40h	0000h	Typical timeout for Min. size buffer write 2^N µs (00h = not supported)
21h	42h	000Ah	Typical timeout per individual block erase 2^N ms
22h	44h	0000h	Typical timeout for full chip erase 2^N ms (00h = not supported)
23h	46h	0005h	Max. timeout for byte/word write 2^N times typical
24h	48h	0000h	Max. timeout for buffer write 2^N times typical
25h	4Ah	0004h	Max. timeout per individual block erase 2^N times typical
26h	4Ch	0000h	Max. timeout for full chip erase 2^N times typical (00h = not supported)

Table 12. Device Geometry Definition

Addresses (Word Mode)	Addresses (Byte Mode)	Data	Description
27h	4Eh	0015h	Device Size = 2^N byte
28h 29h	50h 52h	0002h 0000h	Flash Device Interface description (refer to CFI publication 100)
2Ah 2Bh	54h 56h	0000h 0000h	Max. number of byte in multi-byte write = 2^N (00h = not supported)
2Ch	58h	0002h	Number of Erase Block Regions within device
2Dh 2Eh 2Fh 30h	5Ah 5Ch 5Eh 60h	0007h 0000h 0020h 0000h	Erase Block Region 1 Information (refer to the CFI specification or CFI publication 100)
31h 32h 33h 34h	62h 64h 66h 68h	001Eh 0000h 0000h 0001h	Erase Block Region 2 Information
35h 36h 37h 38h	6Ah 6Ch 6Eh 70h	0000h 0000h 0000h 0000h	Erase Block Region 3 Information
39h 3Ah 3Bh 3Ch	72h 74h 76h 78h	0000h 0000h 0000h 0000h	Erase Block Region 4 Information

Table 13. Primary Vendor-Specific Extended Query

Addresses (Word Mode)	Addresses (Byte Mode)	Data	Description
40h 41h 42h	80h 82h 84h	0050h 0052h 0049h	Query-unique ASCII string “PRI”
43h	86h	0031h	Major version number, ASCII
44h	88h	0032h	Minor version number, ASCII
45h	8Ah	0000h	Address Sensitive Unlock (Bits 1-0) 0 = Required, 1 = Not Required Silicon Revision Number (Bits 7-2)
46h	8Ch	0002h	Erase Suspend 0 = Not Supported, 1 = To Read Only, 2 = To Read & Write
47h	8Eh	0001h	Sector Protect 0 = Not Supported, X = Number of sectors in per group
48h	90h	0001h	Sector Temporary Unprotect 00 = Not Supported, 01 = Supported
49h	92h	0004h	Sector Protect/Unprotect scheme 04 = 29LV800 mode
4Ah	94h	00XXh (See Note)	Simultaneous Operation 00 = Not Supported, X= Number of Sectors in Bank 2 (Uniform Bank)
4Bh	96h	0000h	Burst Mode Type 00 = Not Supported, 01 = Supported
4Ch	98h	0000h	Page Mode Type 00 = Not Supported, 01 = 4 Word Page, 02 = 8 Word Page
4Dh	9Ah	0085h	ACC (Acceleration) Supply Minimum 00h = Not Supported, D7-D4: Volt, D3-D0: 100 mV
4Eh	9Ch	0095h	ACC (Acceleration) Supply Maximum 00h = Not Supported, D7-D4: Volt, D3-D0: 100 mV
4Fh	9Eh	000Xh	Top/Bottom Boot Sector Flag 02h = Bottom Boot Device, 03h = Top Boot Device

Note:
The number of sectors in Bank 2 is device dependent.
Am29DS163 = 18h

COMMAND DEFINITIONS

Writing specific address and data commands or sequences into the command register initiates device operations. Table 14 on page 27 defines the valid register command sequences. Writing **incorrect address and data values** or writing them in the **improper sequence** resets the device to reading array data.

All addresses are latched on the falling edge of WE# or CE#, whichever happens later. All data is latched on the rising edge of WE# or CE#, whichever happens first. Refer to the AC Characteristics section for timing diagrams.

Reading Array Data

The device is automatically set to reading array data after device power-up. No commands are required to retrieve data. Each bank is ready to read array data after completing an Embedded Program or Embedded Erase algorithm.

After the device accepts an Erase Suspend command, the corresponding bank enters the erase-suspend-read mode, after which the system can read data from any non-erase-suspended sector within the same bank. After completing a programming operation in the Erase Suspend mode, the system may once again read array data with the same exception. See the "Erase Suspend/Erase Resume Commands" on page 26 section for more information.

The system *must* issue the reset command to return a bank to the read (or erase-suspend-read) mode if DQ5 goes high during an active program or erase operation, or if the bank is in the autoselect mode. See the next section, "Reset Command", for more information.

See also "Requirements for Reading Array Data" on page 10 for more information. Table on page 36 provides the read parameters, and Figure 13, on page 36 shows the timing diagram.

Reset Command

Writing the reset command resets the banks to the read or erase-suspend-read mode. Address bits are don't cares for this command.

The reset command may be written between the sequence cycles in an erase command sequence before erasing begins. This resets the bank to which the system was writing to reading array data. Once erasure begins, however, the device ignores reset commands until the operation is complete.

The reset command may be written between the sequence cycles in a program command sequence before programming begins. This resets the bank to which the system was writing to reading array data. If the program command sequence is written to a bank that is in the Erase Suspend mode, writing the reset command returns that bank to the erase-suspend-read mode. Once programming begins, however, the device ignores reset commands until the operation is complete.

The reset command may be written between the sequence cycles in an autoselect command sequence. Once in the autoselect mode, the reset command must be written to return to reading array data. If a bank entered the autoselect mode while in the Erase Suspend mode, writing the reset command returns that bank to the erase-suspend-read mode.

If DQ5 goes high during a program or erase operation, writing the reset command returns the banks to reading array data (or erase-suspend-read mode if that bank was in Erase Suspend).

Autoselect Command Sequence

The autoselect command sequence allows the host system to access the manufacturer and device codes, and determine whether or not a sector is protected. Table 14 on page 27 shows the address and data requirements. This method is an alternative to that shown in Table 7 on page 15, which is intended for PROM programmers and requires V_{ID} on address pin A9. The autoselect command sequence may be written to an address within a bank that is either in the read or erase-suspend-read mode. The autoselect command may not be written while the device is actively programming or erasing in the other bank.

The autoselect command sequence is initiated by first writing two unlock cycles. This is followed by a third write cycle that contains the bank address and the autoselect command. The bank then enters the autoselect mode. The system may read at any address within the same bank any number of times without initiating another autoselect command sequence. The following table describes the hex address requirements for the various autoselect functions, and the resulting data. BA represents the bank address, and SA represents the sector address.

Description	Word Address	Byte Address	Read Data*
Manufacturer ID	(BA) + 00	(BA) + 00	01
Device ID	(BA) + 01	(BA) + 02	2295 (top boot) 2296 (bottom boot)
Sector Block Protect Verify	(SA) + 02	(SA) + 04	00 (unlocked), 01 (locked)
SecSi Sector Factory Protect	(BA) + 03	(BA) + 06	85 (factory locked) 05 (not factory locked)

** For byte mode, ignore data output bits D8–DQ15.*

The system must write the reset command to return to reading array data (or erase-suspend-read mode if the bank was previously in Erase Suspend).

Enter SecSi Sector/Exit SecSi Sector Command Sequence

The system can access the SecSi Sector region by issuing the three-cycle Enter SecSi Sector command sequence. The device continues to access the SecSi Sector region until the system issues the four-cycle Exit SecSi Sector command sequence. The Exit SecSi Sector command sequence returns the device to normal operation. Table 14 on page 27 shows the address and data requirements for both command sequences. See also "SecSi (Secured Silicon) Sector Flash Memory Region" on page 19 for further information. Note that a hardware reset (RESET#=V_{IL}) resets the device to reading array data.

Byte/Word Program Command Sequence

The system may program the device by word or byte, depending on the state of the BYTE# pin. Programming is a four-bus-cycle operation. The program command sequence is initiated by writing two unlock write cycles, followed by the program set-up command. The program address and data are written next, which in turn initiate the Embedded Program algorithm. The system is *not* required to provide further controls or timings. The device automatically provides internally generated program pulses and verifies the programmed cell margin. Table 14 on page 27 shows the address and data requirements for the byte program command sequence.

When the Embedded Program algorithm is complete, that bank then returns to reading array data and addresses are no longer latched. The system can determine the status of the program operation by using DQ7, DQ6, or RY/BY#. Refer to "Write Operation Status" on page 28 for information on these status bits.

Any commands written to the device during the Embedded Program Algorithm are ignored. Note that a **hardware reset** immediately terminates the program operation. The program command sequence should be reinitiated once that bank returns to reading array data, to ensure data integrity.

Programming is allowed in any sequence and across sector boundaries. **A bit cannot be programmed from "0" back to a "1."** Attempting to do so may cause that bank to set DQ5 = 1, or cause the DQ7 and DQ6 status bits to indicate the operation was successful. However, a succeeding read shows that the data is still "0." Only erase operations can convert a "0" to a "1."

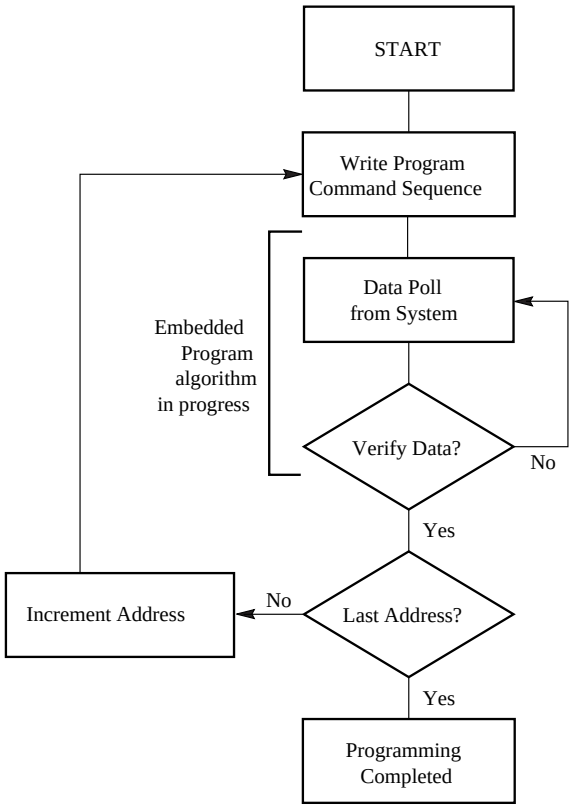
Unlock Bypass Command Sequence

The unlock bypass feature allows the system to program bytes or words to a bank faster than using the standard program command sequence. The unlock bypass command sequence is initiated by first writing two unlock cycles. This is followed by a third write cycle containing the unlock bypass command, 20h. That bank then enters the unlock bypass mode. A two-cycle unlock bypass program command sequence is all that is required to program in this mode. The first cycle in this sequence contains the unlock bypass program command, A0h; the second cycle contains the program address and data. Additional data is programmed in the same manner. This mode dispenses with the initial two unlock cycles required in the standard program command sequence, resulting in faster total programming time. Table 14 on page 27 shows the requirements for the command sequence.

During the unlock bypass mode, only the Unlock Bypass Program and Unlock Bypass Reset commands are valid. To exit the unlock bypass mode, the system must issue the two-cycle unlock bypass reset command sequence. The first cycle must contain the bank address and the data 90h. The second cycle need only contain the data 00h. The bank then returns to the reading array data.

The device offers accelerated program operations through the WP#/ACC pin. When the system asserts V_{HH} on the WP#/ACC pin, the device automatically enters the Unlock Bypass mode. The system may then write the two-cycle Unlock Bypass program command sequence. The device uses the higher voltage on the WP#/ACC pin to accelerate the operation. Note that the WP#/ACC pin must not be at V_{HH} any operation other than accelerated programming, or device damage may result. In addition, the WP#/ACC pin must not be left floating or unconnected; inconsistent behavior of the device may result.

Figure 3, on page 25 illustrates the algorithm for the program operation. Refer to the "Erase and Program Operations" on page 39 for parameters, and Figure 17, on page 40 for timing diagrams.



Note: *See Table 14 for program command sequence.*

Figure 3. Program Operation

Chip Erase Command Sequence

Chip erase is a six bus cycle operation. The chip erase command sequence is initiated by writing two unlock cycles, followed by a set-up command. Two additional unlock write cycles are then followed by the chip erase command, which in turn invokes the Embedded Erase algorithm. The device does *not* require the system to preprogram prior to erase. The Embedded Erase algorithm automatically preprograms and verifies the entire memory for an all zero data pattern prior to electrical erase. The system is not required to provide any controls or timings during these operations. Table 14 shows the address and data requirements for the chip erase command sequence.

When the Embedded Erase algorithm is complete, that bank returns to reading array data and addresses are no longer latched. The system can determine the status of the erase operation by using DQ7, DQ6, DQ2, or RY/BY#. Refer to the Write Operation Status section for information on these status bits.

Any commands written during the chip erase operation are ignored. However, note that a **hardware reset** immediately terminates the erase operation. If that occurs, the chip erase command sequence should be reinitiated once that bank returns to reading array data, to ensure data integrity.

Figure 4, on page 26 illustrates the algorithm for the erase operation. Refer to the "Erase and Program Operations" on page 39 tables in the AC Characteristics section for parameters, and Figure 19, on page 41 section for timing diagrams.

Sector Erase Command Sequence

Sector erase is a six bus cycle operation. The sector erase command sequence is initiated by writing two unlock cycles, followed by a set-up command. Two additional unlock cycles are written, and are then followed by the address of the sector to be erased, and the sector erase command. Table 14 on page 27 shows the address and data requirements for the sector erase command sequence.

The device does *not* require the system to preprogram prior to erase. The Embedded Erase algorithm automatically programs and verifies the entire memory for an all zero data pattern prior to electrical erase. The system is not required to provide any controls or timings during these operations.

After the command sequence is written, a sector erase time-out of 50 µs occurs. During the time-out period, additional sector addresses and sector erase commands may be written. Loading the sector erase buffer may be done in any sequence, and the number of sectors may be from one sector to all sectors. The time between these additional cycles must be less than 50 µs, otherwise erasure may begin. Any sector erase address and command following the exceeded time-out may or may not be accepted. It is recommended that processor interrupts be disabled during this time to ensure all commands are accepted. The interrupts can be re-enabled after the last Sector Erase command is written. **Any command other than Sector Erase or Erase Suspend during the time-out period resets that bank to reading array data.** The system must rewrite the command sequence and any additional addresses and commands.

The system can monitor DQ3 to determine if the sector erase timer timed out (See the section on "DQ3: Sector Erase Timer" on page 30.). The time-out begins from the rising edge of the final WE# pulse in the command sequence.

When the Embedded Erase algorithm is complete, the bank returns to reading array data and addresses are no longer latched. Note that while the Embedded Erase operation is in progress, the system can read data from the non-erasing bank. The system can de-

termine the status of the erase operation by reading DQ7, DQ6, DQ2, or RY/BY# in the erasing bank. Refer to "Write Operation Status" on page 28 for information on these status bits.

Once the sector erase operation starts, only the Erase Suspend command is valid. All other commands are ignored. However, note that a **hardware reset** immediately terminates the erase operation. If that occurs, the sector erase command sequence should be reinitiated once that bank returns to reading array data, to ensure data integrity.

Figure 4 illustrates the algorithm for the erase operation. Refer to the "Erase and Program Operations" on page 39 for parameters, and Figure 19, on page 41 section for timing diagrams.

Erase Suspend/Erase Resume Commands

The Erase Suspend command, B0h, allows the system to interrupt a sector erase operation and then read data from, or program data to, any sector not selected for erasure. The bank address is required when writing this command. This command is valid only during the sector erase operation, including the 50 µs time-out period during the sector erase command sequence. The Erase Suspend command is ignored if written during the chip erase operation or Embedded Program algorithm.

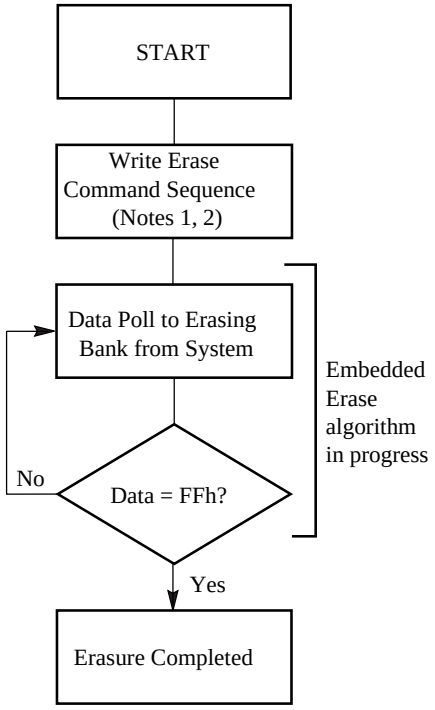
When the Erase Suspend command is written during the sector erase operation, the device requires a maximum of 20 µs to suspend the erase operation. However, when the Erase Suspend command is written during the sector erase time-out, the device immediately terminates the time-out period and suspends the erase operation.

After the erase operation is suspended, the bank enters the erase-suspend-read mode. The system can read data from or program data to any sector not selected for erasure. (The device "erase suspends" all sectors selected for erasure.) Reading at any address within erase-suspended sectors produces status information on DQ7–DQ0. The system can use DQ7, or DQ6 and DQ2 together, to determine if a sector is actively erasing or is erase-suspended. Refer to the "Write Operation Status" on page 28 section for information on these status bits.

After an erase-suspended program operation is complete, the bank returns to the erase-suspend-read mode. The system can determine the status of the program operation using the DQ7 or DQ6 status bits, just as in the standard Byte Program operation. Refer to the "Write Operation Status" on page 28 section for more information.

In the erase-suspend-read mode, the system can also issue the autoselect command sequence. Refer to the "Autoselect Mode" on page 15 and "Autoselect Command Sequence" on page 23 sections for details.

To resume the sector erase operation, the system must write the Erase Resume command. The bank address of the erase-suspended bank is required when writing this command. Further writes of the Resume command are ignored. Another Erase Suspend command can be written after the chip resumes erasing.



Notes:

1. *See Table 14 on page 27 for erase command sequence.*
2. *See the section on DQ3 for information on the sector erase timer.*

Figure 4. Erase Operation

Table 14. Am29DS163D Command Definitions

Command Sequence (Note 1)			Cycles	Bus Cycles (Notes 2–5)											
				First		Second		Third		Fourth		Fifth		Sixth	
				Addr	Data	Addr	Data	Addr	Data	Addr	Data	Addr	Data	Addr	Data
Read (Note 6)			1	RA	RD										
Reset (Note 7)			1	XXX	F0										
Autoselect (Note 8)	Manufacturer ID	Word	4	555	AA	2AA	55	(BA)555	90	(BA)X00	01				
		Byte		AAA		555		(BA)AAA							
	Device ID	Word	4	555	AA	2AA	55	(BA)555	90	(BA)X01	(see Table 7)				
		Byte		AAA		555		(BA)AAA		(BA)X02					
	SecSi Sector Factory Protect (Note 9)	Word	4	555	AA	2AA	55	(BA)555	90	(BA)X03	85/05				
		Byte		AAA		555		(BA)AAA		(BA)X06					
	Sector Protect Verify (Note 10)	Word	4	555	AA	2AA	55	(BA)555	90	(SA)X02	00/01				
		Byte		AAA		555		(BA)AAA		(SA)X04					
Enter SecSi Sector Region		Word	3	555	AA	2AA	55	555	88						
		Byte		AAA		555		AAA							
Exit SecSi Sector Region		Word	4	555	AA	2AA	55	555	90	XXX	00				
		Byte		AAA		555		AAA							
Program		Word	4	555	AA	2AA	55	555	A0	PA	PD				
		Byte		AAA		555		AAA							
Unlock Bypass		Word	3	555	AA	2AA	55	555	20						
		Byte		AAA		555		AAA							
Unlock Bypass Program (Note 11)			2	XXX	A0	PA	PD								
Unlock Bypass Reset (Note 12)			2	BA	90	XXX	00								
Chip Erase		Word	6	555	AA	2AA	55	555	80	555	AA	2AA	55	555	10
		Byte		AAA		555		AAA		AAA		555		AAA	
Sector Erase		Word	6	555	AA	2AA	55	555	80	555	AA	2AA	55	SA	30
		Byte		AAA		555		AAA		AAA		555			
Erase Suspend (Note 13)			1	BA	B0										
Erase Resume (Note 14)			1	BA	30										
CFI Query (Note 15)		Word	1	55	98										
		Byte		AA											

Legend:

X = Don't care

RA = Address of the memory location to be read.

RD = Data read from location RA during read operation.

PA = Address of the memory location to be programmed. Addresses latch on the falling edge of the WE# or CE# pulse, whichever happens later.

PD = Data to be programmed at location PA. Data latches on the rising edge of WE# or CE# pulse, whichever happens first.

SA = Address of the sector to be verified (in autoselect mode) or erased. Address bits A19–A12 uniquely select any sector.

BA = Address of the bank that is being switched to autoselect mode, is in bypass mode, or is being erased.

Notes:

1. *See Table 1 on page 10 for description of bus operations.*
2. *All values are in hexadecimal.*
3. *Except for the read cycle and the fourth cycle of the autoselect command sequence, all bus cycles are write cycles.*
4. *Data bits DQ15–DQ8 are don't care in command sequences, except for RD and PD.*
5. *Unless otherwise noted, address bits A19–A11 are don't cares.*
6. *No unlock or command cycles required when bank is in read mode.*
7. *The Reset command is required to return to reading array data (or to the erase-suspend-read mode if previously in Erase Suspend) when a bank is in the autoselect mode, or if DQ5 goes high (while the bank is providing status information).*
8. *The fourth cycle of the autoselect command sequence is a read cycle. The system must provide the bank address to obtain the manufacturer ID, device ID, or SecSi Sector factory protect information. Data bits DQ15–DQ8 are don't care. See the "Autoselect Command Sequence" on page 23 section for more information.*
9. *The data is 85h for factory locked and 05h for not factory locked.*
10. *The data is 00h for an unprotected sector/sector block and 01h for a protected sector/sector block.*
11. *The Unlock Bypass command is required prior to the Unlock Bypass Program command.*
12. *The Unlock Bypass Reset command is required to return to reading array data when the bank is in the unlock bypass mode.*
13. *The system may read and program in non-erasing sectors, or enter the autoselect mode, when in the Erase Suspend mode. The Erase Suspend command is valid only during a sector erase operation, and requires the bank address.*
14. *The Erase Resume command is valid only during the Erase Suspend mode, and requires the bank address.*
15. *Command is valid when device is ready to read array data or when device is in autoselect mode.*

WRITE OPERATION STATUS

The device provides several bits to determine the status of a program or erase operation: DQ2, DQ3, DQ5, DQ6, and DQ7. Table 15 on page 31 and the following subsections describe the function of these bits. DQ7 and DQ6 each offer a method for determining whether a program or erase operation is complete or in progress. The device also provides a hardware-based output signal, RY/BY#, to determine whether an Embedded Program or Erase operation is in progress or is completed.

DQ7: Data# Polling

The Data# Polling bit, DQ7, indicates to the host system whether an Embedded Program or Erase algorithm is in progress or completed, or whether a bank is in Erase Suspend. Data# Polling is valid after the rising edge of the final WE# pulse in the command sequence.

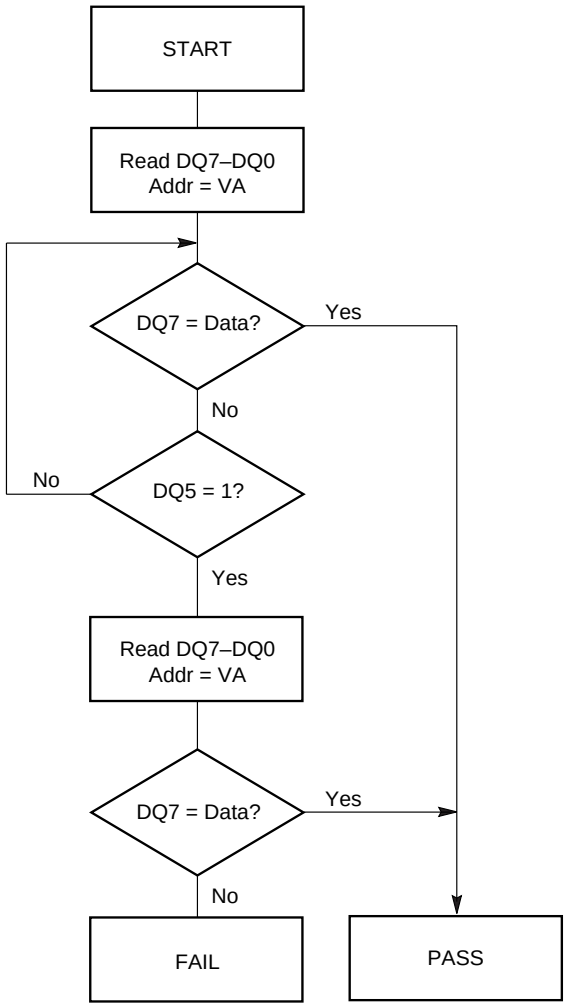
During the Embedded Program algorithm, the device outputs on DQ7 the complement of the datum programmed to DQ7. This DQ7 status also applies to programming during Erase Suspend. When the Embedded Program algorithm is complete, the device outputs the datum programmed to DQ7. The system must provide the program address to read valid status information on DQ7. If a program address falls within a protected sector, Data# Polling on DQ7 is active for approximately 1 µs, then that bank returns to reading array data.

During the Embedded Erase algorithm, Data# Polling produces a “0” on DQ7. When the Embedded Erase algorithm is complete, or if the bank enters the Erase Suspend mode, Data# Polling produces a “1” on DQ7. The system must provide an address within any of the sectors selected for erasure to read valid status information on DQ7.

After an erase command sequence is written, if all sectors selected for erasing are protected, Data# Polling on DQ7 is active for approximately 100 µs, then the bank returns to reading array data. If not all selected sectors are protected, the Embedded Erase algorithm erases the unprotected sectors, and ignores the selected sectors that are protected. However, if the system reads DQ7 at an address within a protected sector, the status may not be valid.

Just prior to the completion of an Embedded Program or Erase operation, DQ7 may change asynchronously with DQ0–DQ6 while Output Enable (OE#) is asserted low. That is, the device may change from providing status information to valid data on DQ7. Depending on when the system samples the DQ7 output, it may read the status or valid data. Even if the device completes the program or erase operation and DQ7 contains valid data, the data outputs on DQ0–DQ6 may be still invalid. Valid data on DQ0–DQ7 appears on successive read cycles.

Table 15 on page 31 shows the outputs for Data# Polling on DQ7. Figure 5 shows the Data# Polling algorithm. Figure 21, on page 42 shows the Data# Polling timing diagram.



Notes:

1. *VA = Valid address for programming. During a sector erase operation, a valid address is any sector address within the sector being erased. During chip erase, a valid address is any non-protected sector address.*
2. *DQ7 should be rechecked even if DQ5 = “1” because DQ7 may change simultaneously with DQ5.*

Figure 5. Data# Polling Algorithm

RY/BY#: Ready/Busy#

The RY/BY# is a dedicated, open-drain output pin which indicates whether an Embedded Algorithm is in progress or complete. The RY/BY# status is valid after the rising edge of the final WE# pulse in the command sequence. Since RY/BY# is an open-drain output, several RY/BY# pins can be tied together in parallel with a pull-up resistor to V_{CC}.

If the output is low (Busy), the device is actively erasing or programming. (This includes programming in the Erase Suspend mode.) If the output is high (Ready), the device is reading array data, the standby mode, or one of the banks is in the erase-suspend-read mode.

Table 15 on page 31 shows the outputs for RY/BY#.

DQ6: Toggle Bit I

Toggle Bit I on DQ6 indicates whether an Embedded Program or Erase algorithm is in progress or complete, or whether the device enters the Erase Suspend mode. Toggle Bit I may be read at any address, and is valid after the rising edge of the final WE# pulse in the command sequence (prior to the program or erase operation), and during the sector erase time-out.

During an Embedded Program or Erase algorithm operation, successive read cycles to any address cause DQ6 to toggle. The system may use either OE# or CE# to control the read cycles. When the operation is complete, DQ6 stops toggling.

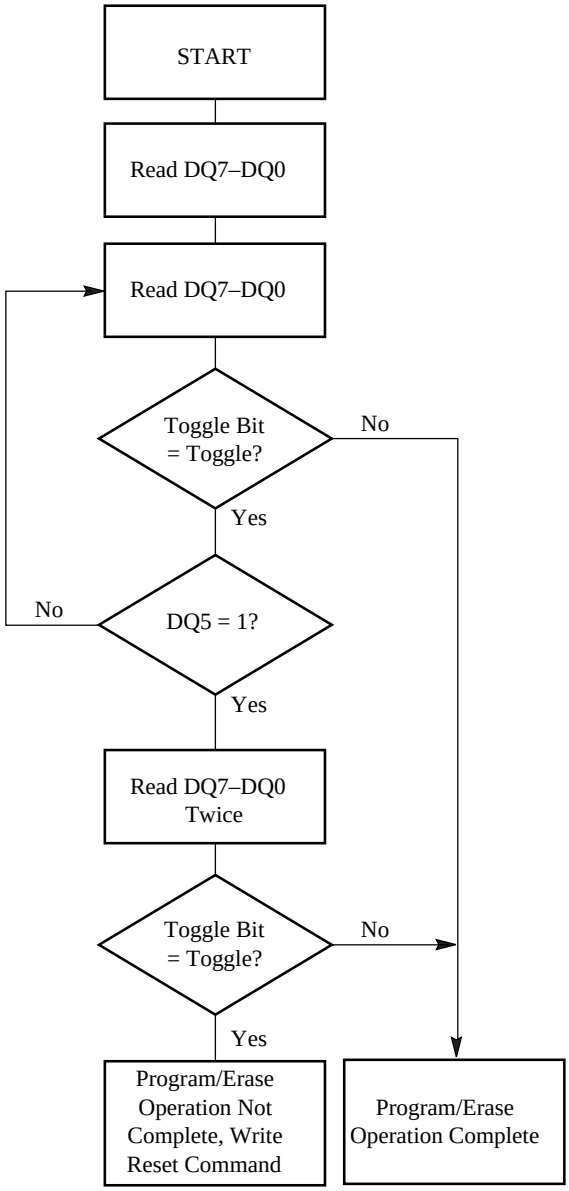
After an erase command sequence is written, if all sectors selected for erasing are protected, DQ6 toggles for approximately 100 µs, then returns to reading array data. If not all selected sectors are protected, the Embedded Erase algorithm erases the unprotected sectors, and ignores the selected sectors that are protected.

The system can use DQ6 and DQ2 together to determine whether a sector is actively erasing or is erase-suspended. When the device is actively erasing (that is, the Embedded Erase algorithm is in progress), DQ6 toggles. When the device enters the Erase Suspend mode, DQ6 stops toggling. However, the system must also use DQ2 to determine which sectors are erasing or erase-suspended. Alternatively, the system can use DQ7 (see the subsection on DQ7: Data# Polling).

If a program address falls within a protected sector, DQ6 toggles for approximately 1 µs after the program command sequence is written, then returns to reading array data.

DQ6 also toggles during the erase-suspend-program mode, and stops toggling once the Embedded Program algorithm is complete.

Table 15 on page 31 shows the outputs for Toggle Bit I on DQ6. Figure 6 shows the toggle bit algorithm. Figure 22, on page 43 shows the toggle bit timing diagrams. Figure 23, on page 43 shows the differences between DQ2 and DQ6 in graphical form. See also the subsection on "DQ2: Toggle Bit II" on page 30.



Note: *The system should recheck the toggle bit even if DQ5 = "1" because the toggle bit may stop toggling as DQ5 changes to "1." See the subsections on DQ6 and DQ2 for more information.*

Figure 6. Toggle Bit Algorithm

DQ2: Toggle Bit II

The “Toggle Bit II” on DQ2, when used with DQ6, indicates whether a particular sector is actively erasing (that is, the Embedded Erase algorithm is in progress), or whether that sector is erase-suspended. Toggle Bit II is valid after the rising edge of the final WE# pulse in the command sequence.

DQ2 toggles when the system reads at addresses within those sectors that were selected for erasure. (The system may use either OE# or CE# to control the read cycles.) But DQ2 cannot distinguish whether the sector is actively erasing or is erase-suspended. DQ6, by comparison, indicates whether the device is actively erasing, or is in Erase Suspend, but cannot distinguish which sectors are selected for erasure. Thus, both status bits are required for sector and mode information. Refer to Table 15 on page 31 to compare outputs for DQ2 and DQ6.

Figure 6, on page 29 shows the toggle bit algorithm in flowchart form, and the section “DQ2: Toggle Bit II” explains the algorithm. See also the “DQ6: Toggle Bit I” on page 29 subsection. Figure 22, on page 43 shows the toggle bit timing diagram. Figure 23, on page 43 shows the differences between DQ2 and DQ6 in graphical form.

Reading Toggle Bits DQ6/DQ2

Refer to Figure 6, on page 29 for the following discussion. Whenever the system initially begins reading toggle bit status, it must read DQ7–DQ0 at least twice in a row to determine whether a toggle bit is toggling. Typically, the system would note and store the value of the toggle bit after the first read. After the second read, the system would compare the new value of the toggle bit with the first. If the toggle bit is not toggling, the device completed the program or erase operation. The system can read array data on DQ7–DQ0 on the following read cycle.

However, if after the initial two read cycles, the system determines that the toggle bit is still toggling, the system also should note whether the value of DQ5 is high (see the section on DQ5). If it is, the system should then determine again whether the toggle bit is toggling, since the toggle bit may have stopped toggling just as DQ5 went high. If the toggle bit is no longer toggling, the device successfully completed the program or erase operation. If it is still toggling, the device did not completed the operation successfully, and the system must write the reset command to return to reading array data.

The remaining scenario is that the system initially determines that the toggle bit is toggling and DQ5 did not go high. The system may continue to monitor the toggle bit and DQ5 through successive read cycles, determining the status as described in the previous paragraph. Alternatively, it may choose to perform other system tasks. In this case, the system must start at the beginning of the algorithm when it returns to determine the status of the operation (top of Figure 6, on page 29).

DQ5: Exceeded Timing Limits

DQ5 indicates whether the program or erase time exceeded a specified internal pulse count limit. Under these conditions DQ5 produces a “1,” indicating that the program or erase cycle was not successfully completed.

The device may output a “1” on DQ5 if the system tries to program a “1” to a location that was previously programmed to “0.” **Only an erase operation can change a “0” back to a “1.”** Under this condition, the device halts the operation, and when the timing limit is exceeded, DQ5 produces a “1.”

Under both these conditions, the system must write the reset command to return to reading array data (or to the erase-suspend-read mode if a bank was previously in the erase-suspend-program mode).

DQ3: Sector Erase Timer

After writing a sector erase command sequence, the system may read DQ3 to determine whether or not erasure started. (The sector erase timer does not apply to the chip erase command.) If additional sectors are selected for erasure, the entire time-out also applies after each additional sector erase command. When the time-out period is complete, DQ3 switches from a “0” to a “1.” If the time between additional sector erase commands from the system can be assumed to be less than 50 µs, the system need not monitor DQ3. See also “Sector Erase Command Sequence” on page 25.

After the sector erase command is written, the system should read the status of DQ7 (Data# Polling) or DQ6 (Toggle Bit I) to ensure that the device accepted the command sequence, and then read DQ3. If DQ3 is “1,” the Embedded Erase algorithm started; all further commands (except Erase Suspend) are ignored until the erase operation is complete. If DQ3 is “0,” the device accepts additional sector erase commands. To ensure the command is accepted, the system software should check the status of DQ3 prior to and following each subsequent sector erase command. If DQ3 is high on the second status check, the last command might not have been accepted.

Table 15 on page 31 shows the status of DQ3 relative to the other status bits.

Table 15. Write Operation Status

Status			DQ7 (Note 2)	DQ6	DQ5 (Note 1)	DQ3	DQ2 (Note 2)	RY/BY#
Standard Mode	Embedded Program Algorithm		DQ7#	Toggle	0	N/A	No toggle	0
	Embedded Erase Algorithm		0	Toggle	0	1	Toggle	0
Erase Suspend Mode	Erase-Suspend-Read	Erase Suspended Sector	1	No toggle	0	N/A	Toggle	1
		Non-Erase Suspended Sector	Data	Data	Data	Data	Data	1
	Erase-Suspend-Program		DQ7#	Toggle	0	N/A	N/A	0

Notes:

1. *DQ5 switches to '1' when an Embedded Program or Embedded Erase operation exceeds the maximum timing limits. Refer to the section on DQ5 for more information.*
2. *DQ7 and DQ2 require a valid address when reading status information. Refer to the appropriate subsection for further details.*
3. *When reading write operation status bits, the system must always provide the bank address where the Embedded Algorithm is in progress. The device outputs array data if the system addresses a non-busy bank.*

ABSOLUTE MAXIMUM RATINGS

Storage Temperature
Plastic Packages . . . . . –65°C to +150°C

Ambient Temperature
with Power Applied . . . . . –65°C to +125°C

Voltage with Respect to Ground

V_{CC} (Note 1) . . . . . –0.5 V to +2.5 V

A9, OE#, and RESET#
(Note 2) . . . . . –0.5 V to +11 V

WP#/ACC . . . . . –0.5 V to +10.5 V

All other pins (Note 1) . . . . . –0.5 V to V_{CC} +0.5 V

Output Short Circuit Current (Note 3) . . . . . 100 mA

Notes:

1. *Minimum DC voltage on input or I/O pins is –0.5 V. During voltage transitions, input or I/O pins may overshoot V_{SS} to –2.0 V for periods of up to 20 ns. Maximum DC voltage on input or I/O pins is V_{CC} +0.5 V. See Figure 7. During voltage transitions, input or I/O pins may overshoot to V_{CC} +2.0 V for periods up to 20 ns. See Figure 8.*
2. *Minimum DC input voltage on pins A9, OE#, RESET#, and WP#/ACC is –0.5 V. During voltage transitions, A9, OE#, WP#/ACC, and RESET# may overshoot V_{SS} to –2.0 V for periods of up to 20 ns. See Figure 7. Maximum DC input voltage on pin A9 is +12.5 V which may overshoot to +14.0 V for periods up to 20 ns. Maximum DC input voltage on WP#/ACC is +9.5 V which may overshoot to +12.0 V for periods up to 20 ns.*
3. *No more than one output may be shorted to ground at a time. Duration of the short circuit should not be greater than one second.*

Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational sections of this data sheet is not implied. Exposure of the device to absolute maximum rating conditions for extended periods may affect device reliability.

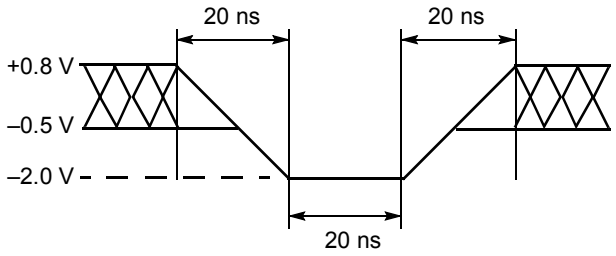


Figure 7. Maximum Negative Overshoot Waveform

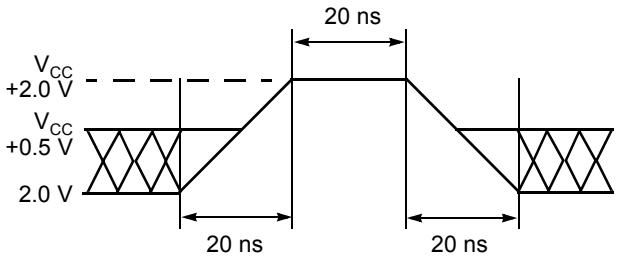


Figure 8. Maximum Positive Overshoot Waveform

OPERATING RANGES

Commercial (C) Devices

Ambient Temperature (T_A) . . . . . 0°C to +70°C

Industrial (I) Devices

Ambient Temperature (T_A) . . . . . –40°C to +85°C

Extended (E) Devices

Ambient Temperature (T_A) . . . . . –55°C to +125°C

V_{CC} Supply Voltages

V_{CC} for standard voltage range . . . . . 1.8 V to 2.2 V

Operating ranges define those limits between which the functionality of the device is guaranteed.

DC CHARACTERISTICS

CMOS Compatible

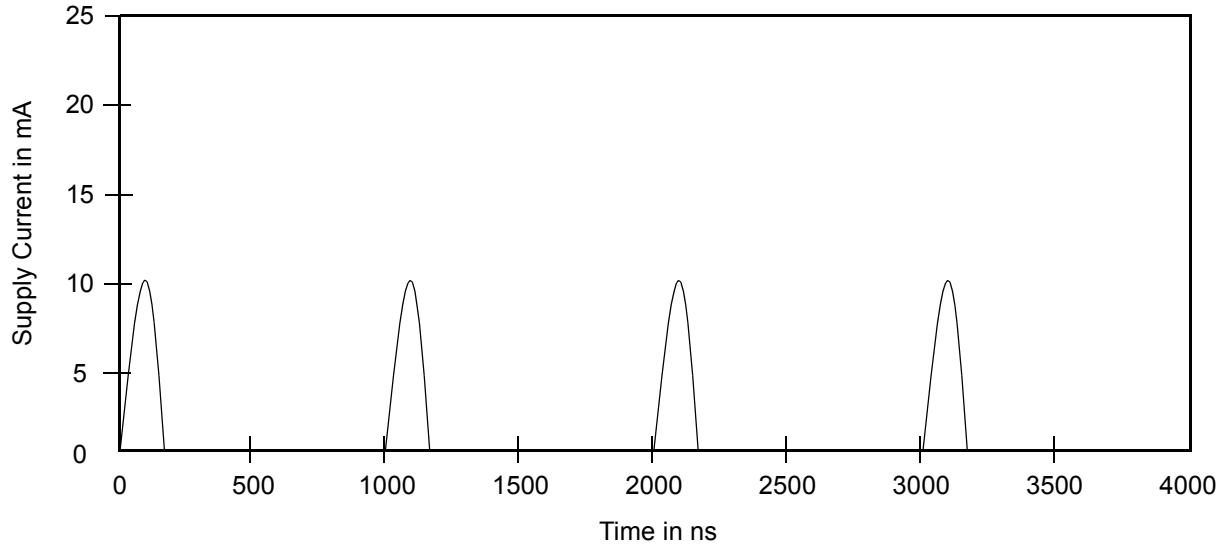
Parameter Symbol	Parameter Description	Test Conditions		Min	Typ	Max	Unit
I_{LI}	Input Load Current	$V_{IN} = V_{SS}$ to V_{CC}, $V_{CC} = V_{CC\ max}$				±1.0	µA
I_{LIT}	A9 Input Load Current	$V_{CC} = V_{CC\ max}$; A9 = 11 V				35	µA
I_{LO}	Output Leakage Current	$V_{OUT} = V_{SS}$ to V_{CC}, $V_{CC} = V_{CC\ max}$				±1.0	µA
I_{CC1}	V_{CC} Active Read Current (Notes 1, 2)	CE# = $V_{IL,}$ OE# = V_{IH}, Byte Mode	5 MHz		5	16	mA
			1 MHz		1	4	
		CE# = $V_{IL,}$ OE# = V_{IH}, Word Mode	5 MHz		5	16	
			1 MHz		1	4	
I_{CC2}	V_{CC} Active Write Current (Notes 2, 3)	CE# = $V_{IL,}$ OE# = V_{IH}, WE# = V_{IL}			10	15	mA
I_{CC3}	V_{CC} Standby Current (Note 2)	CE#, RESET# = V_{CC} ± 0.3 V			0.2	5	µA
I_{CC4}	V_{CC} Reset Current (Note 2)	RESET# = V_{SS} ± 0.3 V			0.2	5	µA
I_{CC5}	Automatic Sleep Mode (Notes 2, 4)	$V_{IH} = V_{CC}$ ± 0.3 V; $V_{IL} = V_{SS}$ ± 0.3 V			0.2	5	µA
I_{CC6}	V_{CC} Active Read-While-Program Current (Notes 1, 2)	CE# = V_{IL}, OE# = V_{IH}	Byte		15	25	mA
			Word		15	25	
I_{CC7}	V_{CC} Active Read-While-Erase Current (Notes 1, 2)	CE# = V_{IL}, OE# = V_{IH}	Byte		15	25	mA
			Word		15	25	
I_{CC8}	V_{CC} Active Program-While-Erase-Suspended Current (Notes 2, 5)	CE# = V_{IL}, OE# = V_{IH}			10	15	mA
I_{ACC}	ACC Accelerated Program Current, Word or Byte	CE# = V_{IL}, OE# = V_{IH}	ACC pin		5	10	mA
			V_{CC} pin		10	15	mA
V_{IL}	Input Low Voltage			–0.5		V_{CC} x 0.2	V
V_{IH}	Input High Voltage			0.8 x V_{CC}		V_{CC} + 0.3	V
V_{HH}	Voltage for WP#/ACC Sector Protect/Unprotect and Program Acceleration	V_{CC} = 1.8–2.2 V		8.5		9.5	V
V_{ID}	Voltage for Autoselect and Temporary Sector Unprotect	V_{CC} = 1.8–2.2 V		9.0		11.0	V
V_{OL}	Output Low Voltage	I_{OL} = 2.0 mA, $V_{CC} = V_{CC\ min}$				0.25	V
V_{OH1}	Output High Voltage	I_{OH} = –2.0 mA, $V_{CC} = V_{CC\ min}$		0.7 V_{CC}			V
V_{OH2}		I_{OH} = –100 µA, $V_{CC} = V_{CC\ min}$		V_{CC}–0.1			
V_{LKO}	Low V_{CC} Lock-Out Voltage (Note 5)			1.2		1.6	V

Notes:

1. *The I_{CC} current listed is typically less than 1 mA/MHz, with OE# at V_{IH}.*
2. *Maximum I_{CC} specifications are tested with $V_{CC} = V_{CC}$max.*
3. *I_{CC} active while Embedded Erase or Embedded Program is in progress.*
4. *Automatic sleep mode enables the low power mode when addresses remain stable for t_{ACC} + 30 ns. Typical sleep mode current is 200 nA.*
5. *Not 100% tested.*

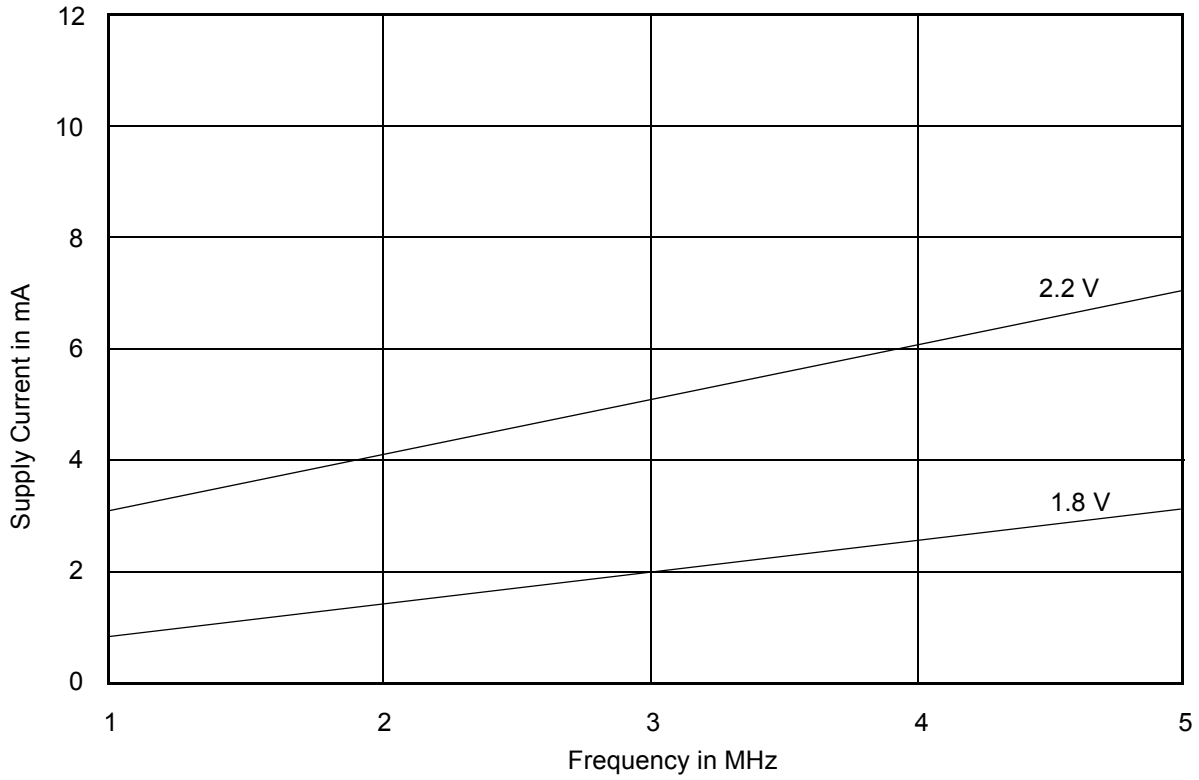
DC CHARACTERISTICS

Zero-Power Flash



Note: *Addresses are switching at 1 MHz*

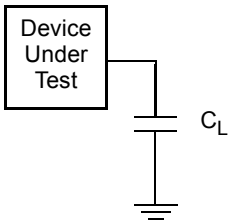
Figure 9. I_{CC1} Current vs. Time (Showing Active and Automatic Sleep Currents)



Note: *T = 25 °C*

Figure 10. Typical I_{CC1} vs. Frequency

TEST CONDITIONS



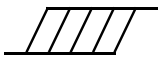
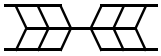
Note: *Diodes are IN3064 or equivalent*

Figure 11. Test Setup

Table 16. Test Specifications

Test Condition	100, 120	Unit
Output Load	1 TTL gate	
Output Load Capacitance, C_L (including jig capacitance)	30	pF
Input Rise and Fall Times	5	ns
Input Pulse Levels	0.0–2.0 V	V
Input timing measurement reference levels	1.0	V
Output timing measurement reference levels	1.0	V

Key To Switching Waveforms

WAVEFORM	INPUTS	OUTPUTS
	Steady	
	Changing from H to L	
	Changing from L to H	
	Don’t Care, Any Change Permitted	Changing, State Unknown
	Does Not Apply	Center Line is High Impedance State (High Z)

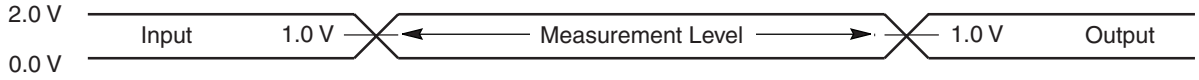


Figure 12. Input Waveforms and Measurement Levels

AC CHARACTERISTICS

Read-Only Operations

Parameter		Description		Test Setup		100	120	Unit
JEDEC	Std							
t_{AVAV}	t_{RC}	Read Cycle Time (Note 1)			Min	100	120	ns
t_{AVQV}	t_{ACC}	Address to Output Delay		CE#, OE# = V_{IL}	Max	100	120	ns
t_{ELQV}	t_{CE}	Chip Enable to Output Delay		OE# = V_{IL}	Max	100	120	ns
t_{GLQV}	t_{OE}	Output Enable to Output Delay			Max	35	50	ns
t_{EHQZ}	t_{DF}	Chip Enable to Output High Z (Note 1)			Max	30		ns
t_{GHQZ}	t_{DF}	Output Enable to Output High Z (Note 1)			Max	30		ns
t_{AXQX}	t_{OH}	Output Hold Time From Addresses, CE# or OE#, Whichever Occurs First			Min	0		ns
	t_{OEH}	Output Enable Hold Time (Note 1)	Read		Min	0		ns
			Toggle and Data# Polling		Min	10		ns

Notes:

1. *Not 100% tested.*
2. *See Figure 11 and Table 16 for test specifications.*

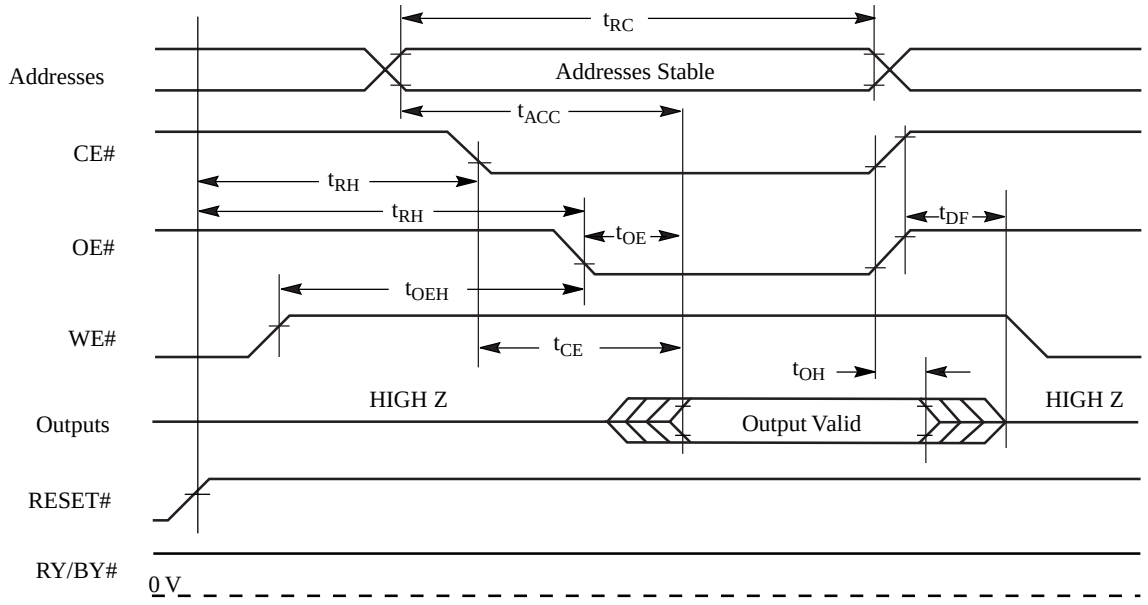


Figure 13. Read Operation Timings

AC CHARACTERISTICS

Hardware Reset (RESET#)

Parameter		Description		All Speed Options	Unit
JEDEC	Std				
	t_{Ready}	RESET# Pin Low (During Embedded Algorithms) to Read Mode (See Note)	Max	20	µs
	t_{Ready}	RESET# Pin Low (NOT During Embedded Algorithms) to Read Mode (See Note)	Max	500	ns
	t_{RP}	RESET# Pulse Width	Min	500	ns
	t_{RH}	Reset High Time Before Read (See Note)	Min	200	ns
	t_{RPD}	RESET# Low to Standby Mode	Min	20	µs
	t_{RB}	RY/BY# Recovery Time	Min	0	ns

Note: *Not 100% tested.*

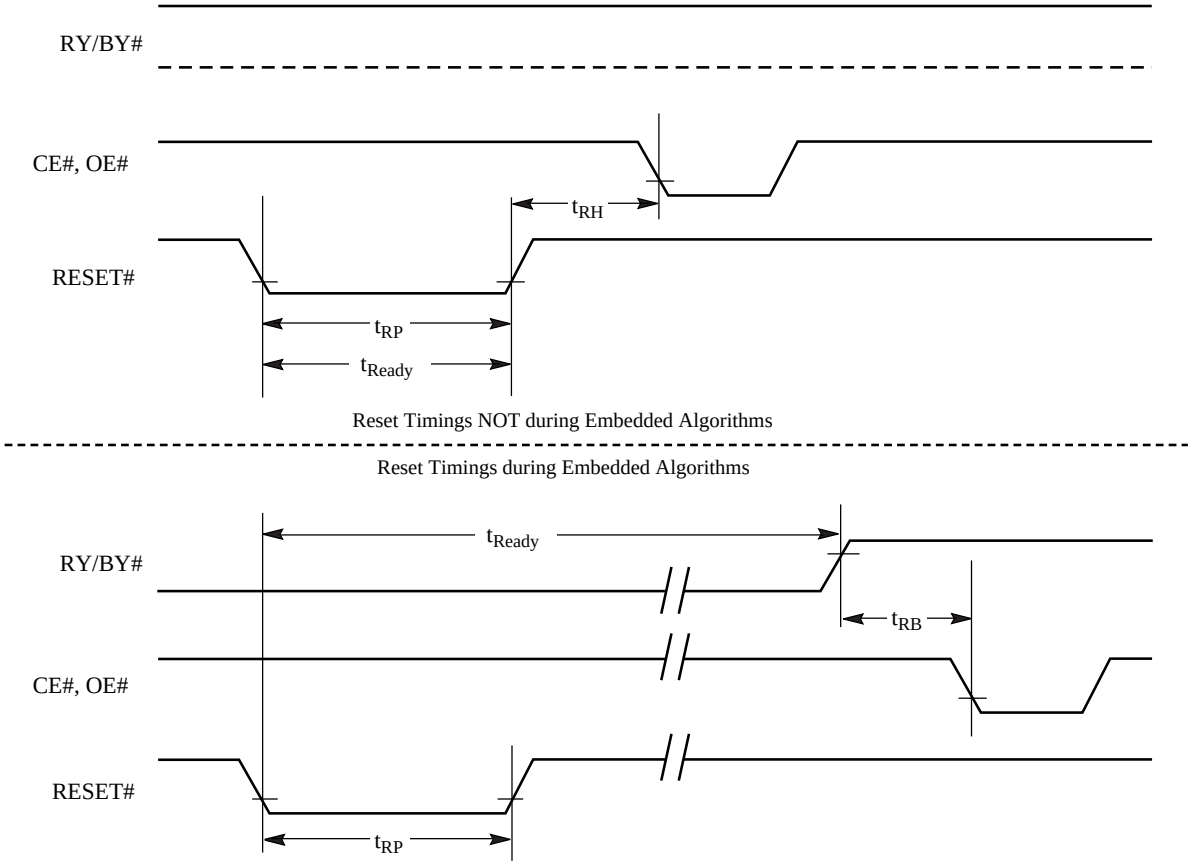


Figure 14. Reset Timings

AC CHARACTERISTICS

Word/Byte Configuration (BYTE#)

Parameter						
JEDEC	Std	Description		100	120	Unit
	t_{ELFL}/t_{ELFH}	CE# to BYTE# Switching Low or High	Max	10		ns
	t_{FLQZ}	BYTE# Switching Low to Output HIGH Z	Max	40	40	ns
	t_{FHQV}	BYTE# Switching High to Output Active	Min	100	120	ns

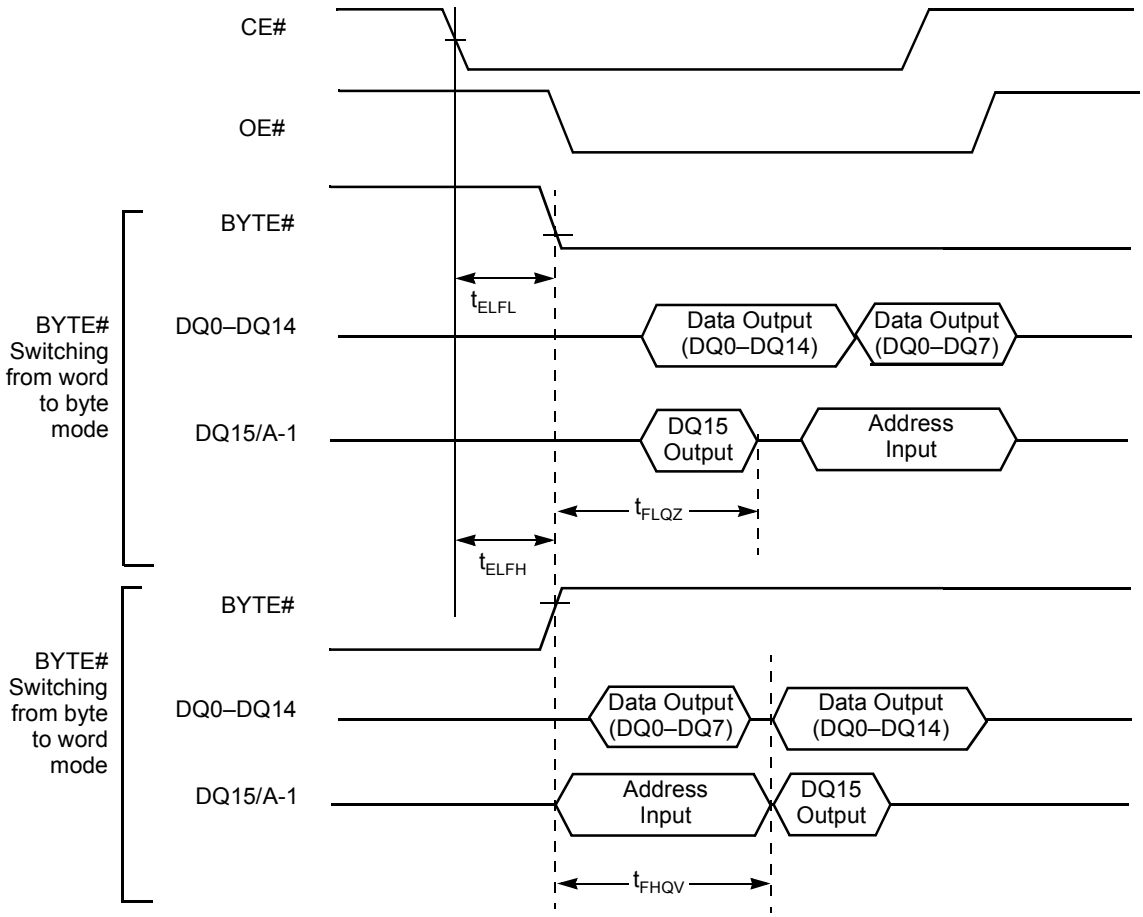
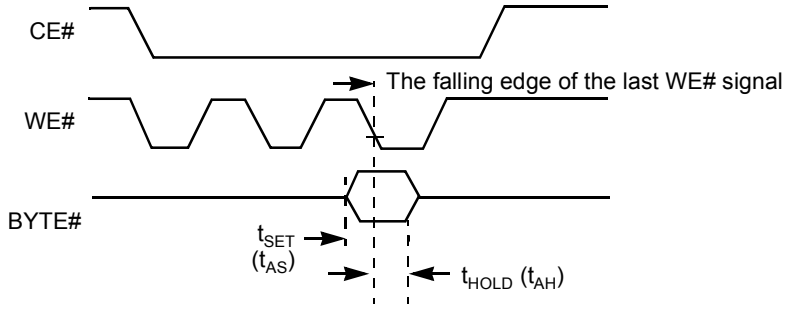


Figure 15. BYTE# Timings for Read Operations



Note: *Refer to the Erase/Program Operations table for t_{AS} and t_{AH} specifications.*

Figure 16. BYTE# Timings for Write Operations

AC CHARACTERISTICS

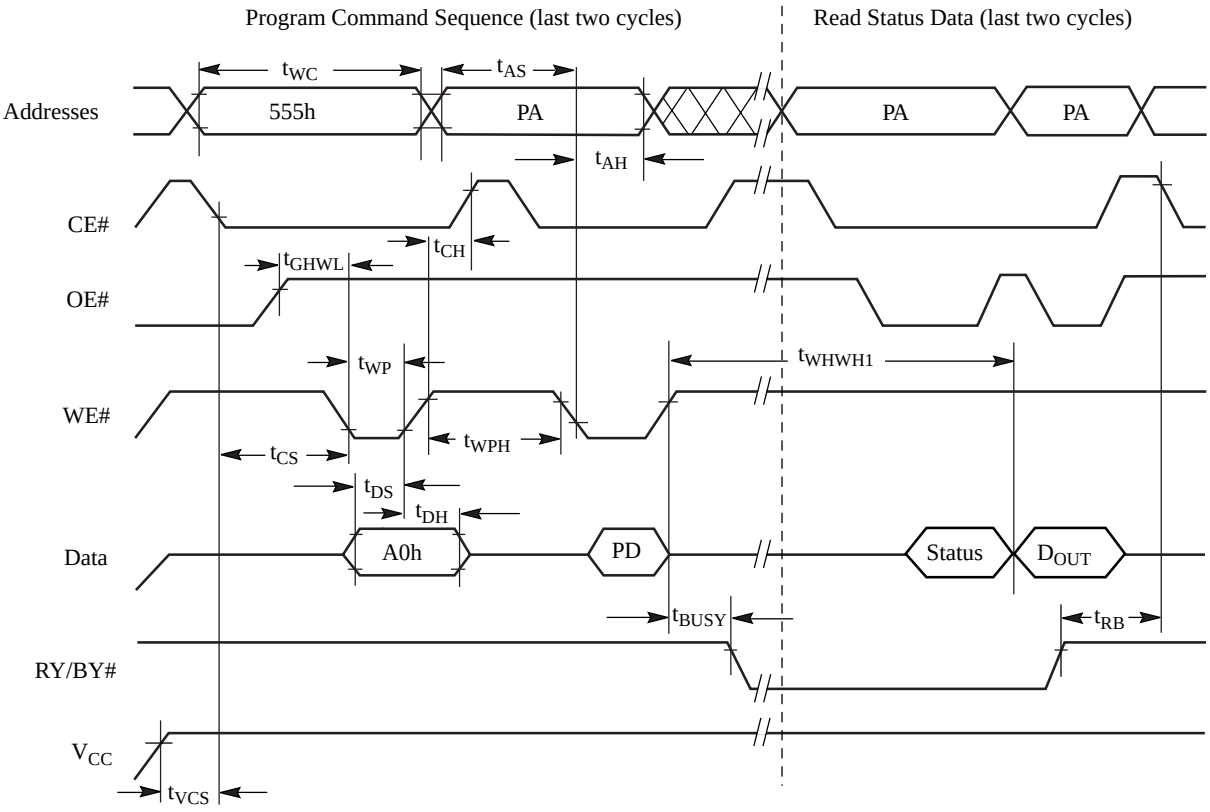
Erase and Program Operations

Parameter							
JEDEC	Std	Description			100	120	Unit
t_{AVAV}	t_{WC}	Write Cycle Time (Note 1)		Min	100	120	ns
t_{AVWL}	t_{AS}	Address Setup Time		Min	0	0	ns
	t_{ASO}	Address Setup Time to OE# low during toggle bit polling		Min	15		ns
t_{WLAX}	t_{AH}	Address Hold Time		Min	50		ns
	t_{AHT}	Address Hold Time From CE# or OE# high during toggle bit polling		Min	0		ns
t_{DVWH}	t_{DS}	Data Setup Time		Min	50		ns
t_{WHDX}	t_{DH}	Data Hold Time		Min	0		ns
	t_{OEPH}	Output Enable High during toggle bit polling		Min	20		ns
t_{GHWL}	t_{GHWL}	Read Recovery Time Before Write (OE# High to WE# Low)		Min	0		ns
t_{ELWL}	t_{CS}	CE# Setup Time		Min	0		ns
t_{WHEH}	t_{CH}	CE# Hold Time		Min	0		ns
t_{WLWH}	t_{WP}	Write Pulse Width		Min	50		ns
t_{WHDL}	t_{WPH}	Write Pulse Width High		Min	30		ns
	$t_{SR/W}$	Latency Between Read and Write Operations		Min	0		ns
t_{WHWH1}	t_{WHWH1}	Programming Operation (Note 2)	Byte	Typ	9		µs
			Word	Typ	13		
t_{WHWH1}	t_{WHWH1}	Accelerated Programming Operation, Word or Byte (Note 2)		Typ	7		µs
t_{WHWH2}	t_{WHWH2}	Sector Erase Operation (Note 2)		Typ	2		sec
	t_{VCS}	V_{CC} Setup Time (Note 1)		Min	50		µs
	t_{RB}	Write Recovery Time from RY/BY#		Min	0		ns
	t_{BUSY}	Program/Erase Valid to RY/BY# Delay		Min	90		ns

Notes:

1. *Not 100% tested.*
2. *See "Erase And Programming Performance" on page 48 for more information.*

AC CHARACTERISTICS



Notes:

1. *PA = program address, PD = program data, D_{OUT} is the true data at the program address.*
2. *Illustration shows device in word mode.*

Figure 17. Program Operation Timings

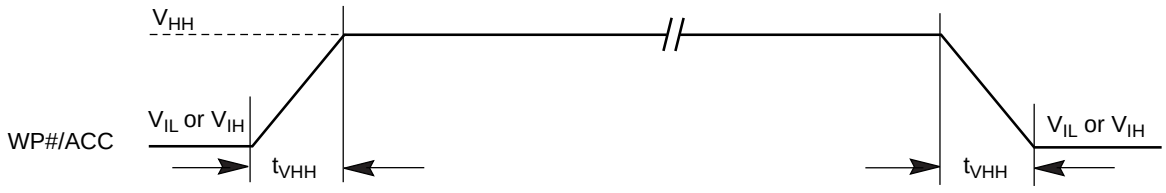
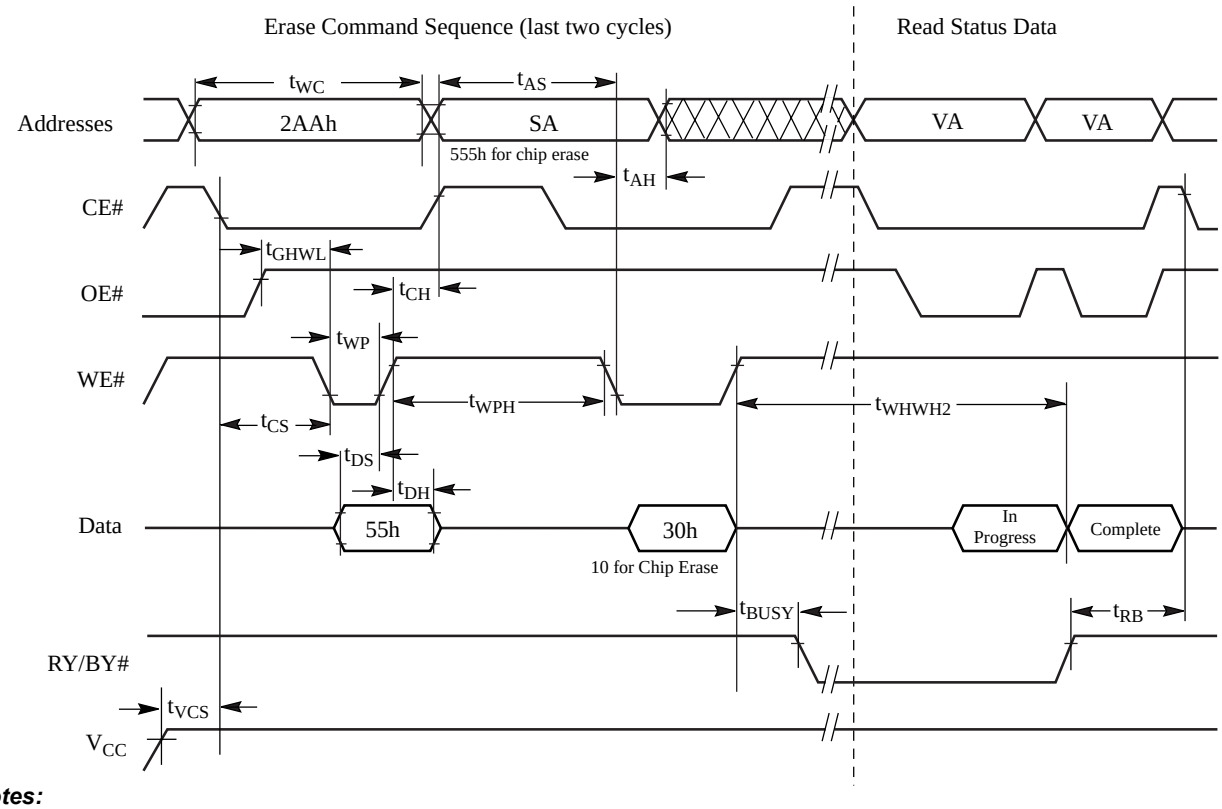


Figure 18. Accelerated Program Timing Diagram

AC CHARACTERISTICS



Notes:

1. *SA = sector address (for Sector Erase), VA = Valid Address for reading status data (see "Write Operation Status" on page 28).*
2. *These waveforms are for the word mode.*

Figure 19. Chip/Sector Erase Operation Timings

AC CHARACTERISTICS

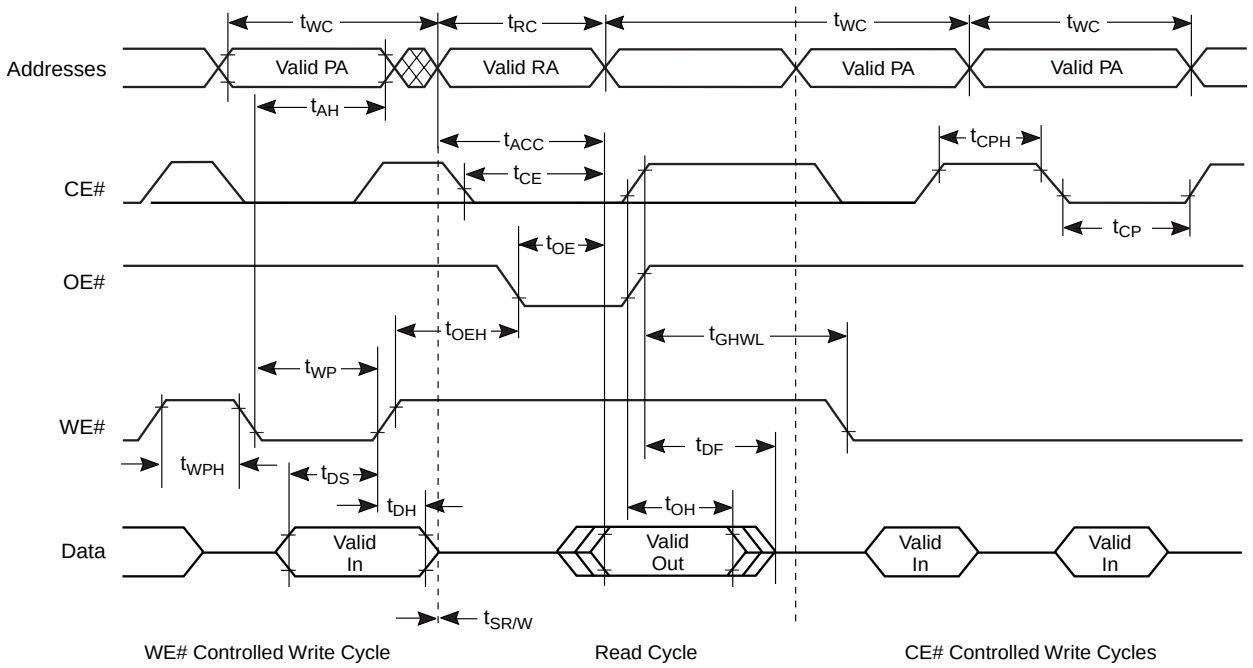
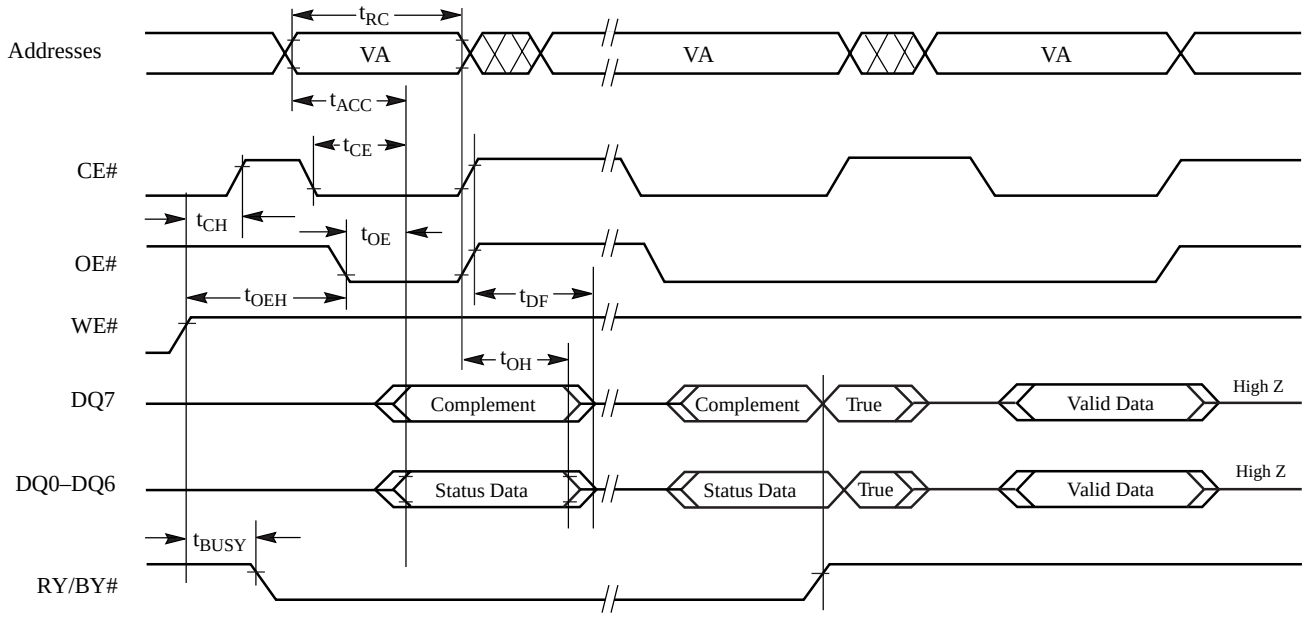


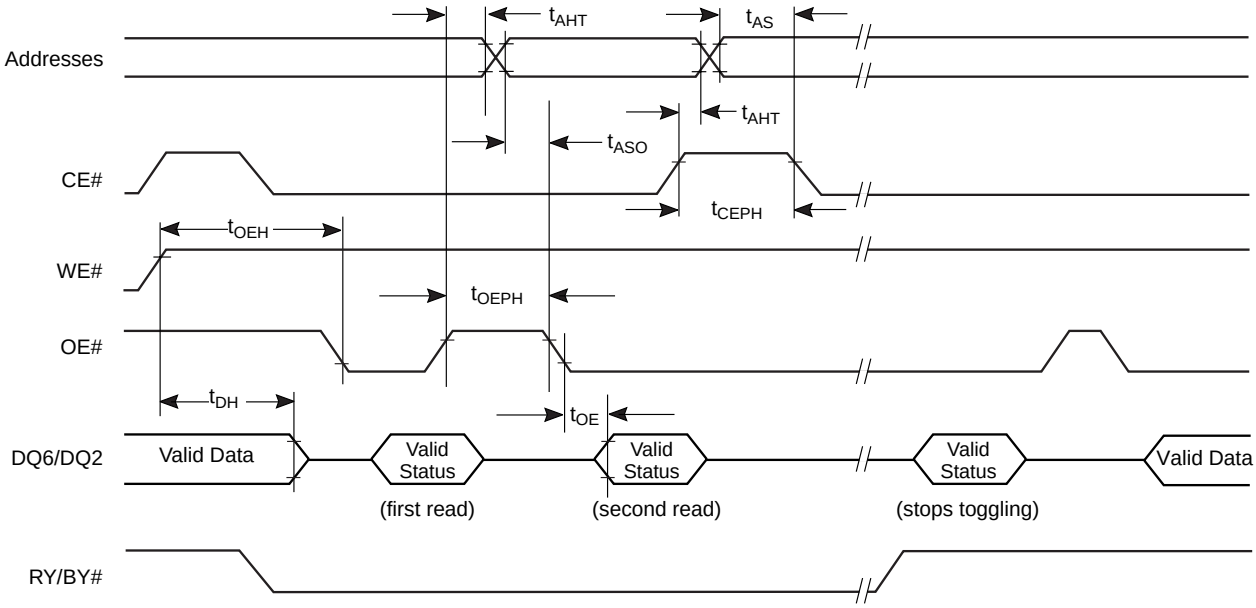
Figure 20. Back-to-back Read/Write Cycle Timings



Note: *VA = Valid address. Illustration shows first status cycle after command sequence, last status read cycle, and array data read cycle.*

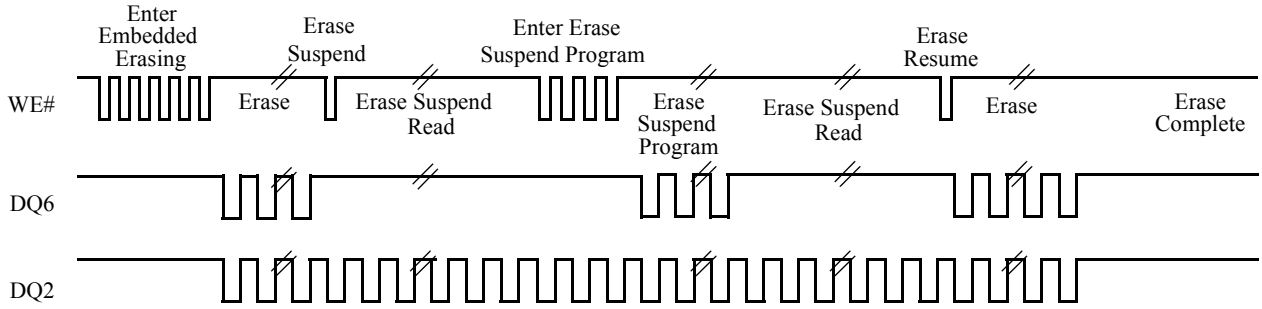
Figure 21. Data# Polling Timings (During Embedded Algorithms)

AC CHARACTERISTICS



Note: *VA = Valid address; not required for DQ6. Illustration shows first two status cycle after command sequence, last status read cycle, and array data read cycle*

Figure 22. Toggle Bit Timings (During Embedded Algorithms)



Note: *DQ2 toggles only when read at an address within an erase-suspended sector. The system may use OE# or CE# to toggle DQ2 and DQ6.*

Figure 23. DQ2 vs. DQ6

AC CHARACTERISTICS

Temporary Sector/Sector Block Unprotect

Parameter					
JEDEC	Std	Description		All Speed Options	Unit
	t_{VIDR}	V_{ID} Rise and Fall Time (See Note)	Min	500	ns
	t_{VHH}	V_{HH} Rise and Fall Time (See Note)	Min	500	ns
	t_{RSP}	RESET# Setup Time for Temporary Sector/Sector Block Unprotect	Min	4	µs
	t_{RRB}	RESET# Hold Time from RY/BY# High for Temporary Sector/Sector Block Unprotect	Min	4	µs

Note: *Not 100% tested.*

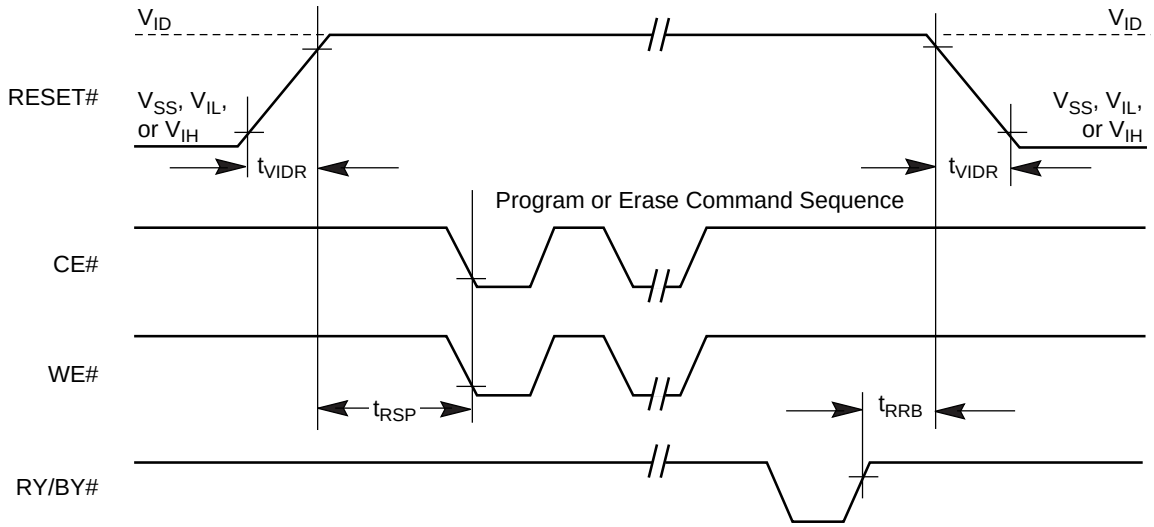
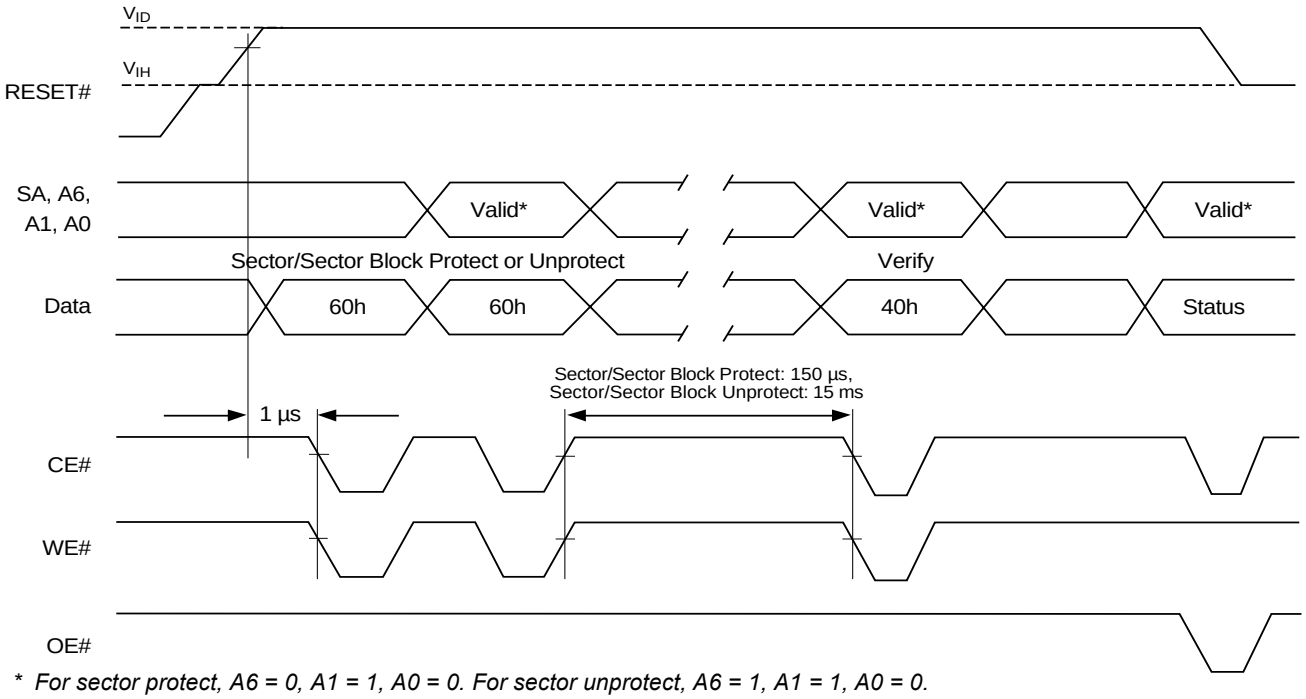


Figure 24. Temporary Sector/Sector Block Unprotect Timing Diagram

AC CHARACTERISTICS



* *For sector protect, A6 = 0, A1 = 1, A0 = 0. For sector unprotect, A6 = 1, A1 = 1, A0 = 0.*

Figure 25. Sector/Sector Block Protect/Unprotect Timing Diagram

AC CHARACTERISTICS

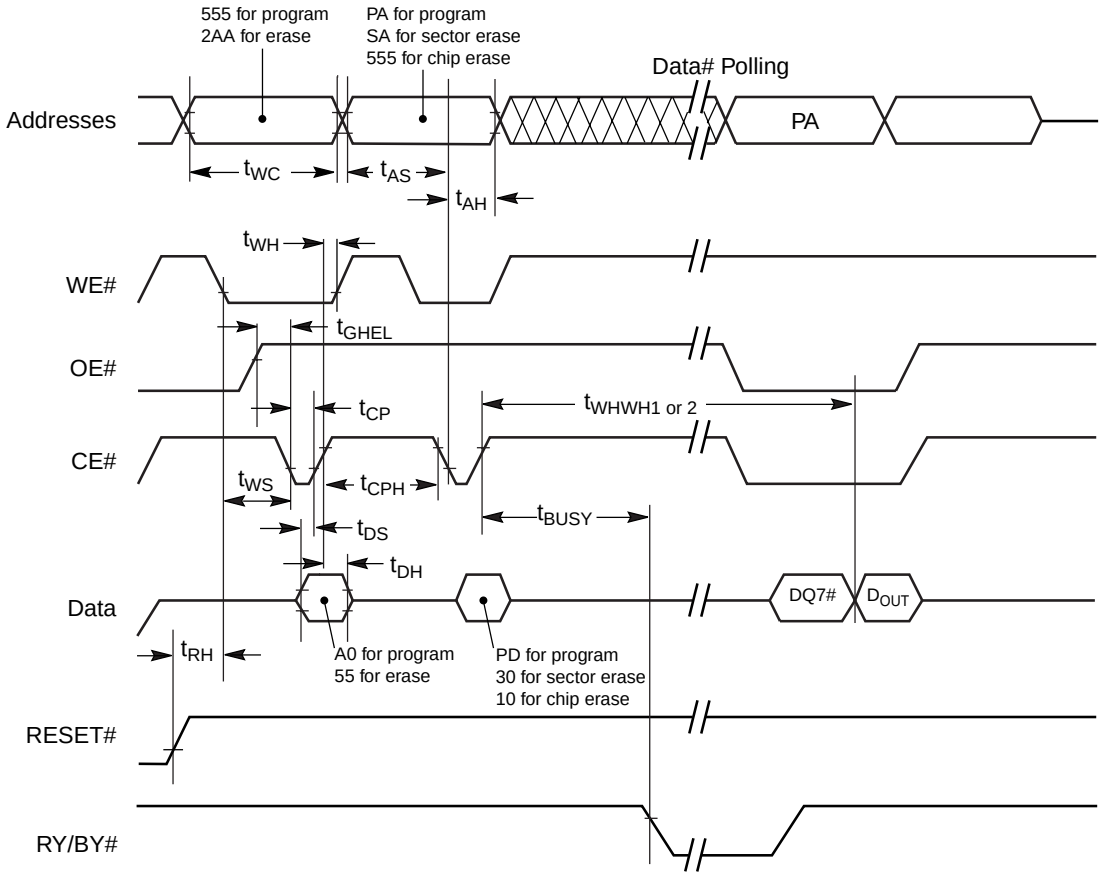
Alternate CE# Controlled Erase and Program Operations

Parameter		Description			100	120	Unit
JEDEC	Std						
t_{AVAV}	t_{WC}	Write Cycle Time (Note 1)		Min	100	120	ns
t_{AVWL}	t_{AS}	Address Setup Time		Min	0		ns
t_{ELAX}	t_{AH}	Address Hold Time		Min	50		ns
t_{DVEH}	t_{DS}	Data Setup Time		Min	50		ns
t_{EHDX}	t_{DH}	Data Hold Time		Min	0		ns
t_{GHEL}	t_{GHEL}	Read Recovery Time Before Write (OE# High to WE# Low)		Min	0		ns
t_{WLEL}	t_{WS}	WE# Setup Time		Min	0		ns
t_{EHWH}	t_{WH}	WE# Hold Time		Min	0		ns
t_{ELEH}	t_{CP}	CE# Pulse Width		Min	50		ns
t_{EHEL}	t_{CPH}	CE# Pulse Width High		Min	30		ns
t_{WHWH1}	t_{WHWH1}	Programming Operation (Note 2)	Byte	Typ	9		µs
			Word	Typ	13		
t_{WHWH1}	t_{WHWH1}	Accelerated Programming Operation, Word or Byte (Note 2)		Typ	7		µs
t_{WHWH2}	t_{WHWH2}	Sector Erase Operation (Note 2)		Typ	2		sec

Notes:

1. *Not 100% tested.*
2. *See "Erase And Programming Performance" on page 48 for more information.*

AC CHARACTERISTICS



Notes:

1. *Figure indicates last two bus cycles of a program or erase operation.*
2. *PA = program address, SA = sector address, PD = program data.*
3. *DQ7# is the complement of the data written to the device. D_{OUT} is the data written to the device.*
4. *Waveforms are for the word mode.*

Figure 26. Alternate CE# Controlled Write (Erase/Program) Operation Timings

ERASE AND PROGRAMMING PERFORMANCE

Parameter		Typ (Note 1)	Max (Note 2)	Unit	Comments
Sector Erase Time		2	15	sec	Excludes 00h programming prior to erasure (Note 4)
Chip Erase Time		78		sec	
Byte Program Time		9	270	µs	Excludes system level overhead (Note 5)
Word Program Time		13	340	µs	
Accelerated Byte/Word Program Time		7	210	µs	
Chip Program Time (Note 3)	Byte Mode	28	80	sec	
	Word Mode	14	40		

Notes:

1. *Typical program and erase times assume the following conditions: 25°C, 2.0 V V_{CC}, 1,000,000 cycles. Additionally, programming typicals assume checkerboard pattern.*
2. *Under worst case conditions of 90°C, V_{CC} = 2.2 V, 1,000,000 cycles.*
3. *The typical chip programming time is considerably less than the maximum chip programming time listed, since most bytes program faster than the maximum program times listed.*
4. *In the pre-programming step of the Embedded Erase algorithm, all bytes are programmed to 00h before erasure.*
5. *System-level overhead is the time required to execute the two- or four-bus-cycle sequence for the program command. See Table 14 on page 27 for further information on command definitions.*
6. *The device has a minimum erase and program cycle endurance of 1,000,000 cycles.*

LATCHUP CHARACTERISTICS

Description	Min	Max
Input voltage with respect to V_{SS} on all pins except I/O pins (including A9, OE#, and RESET#)	–1.0 V	11 V
Input voltage with respect to V_{SS} on all I/O pins	–1.0 V	V_{CC} + 1.0 V
V_{CC} Current	–100 mA	+100 mA

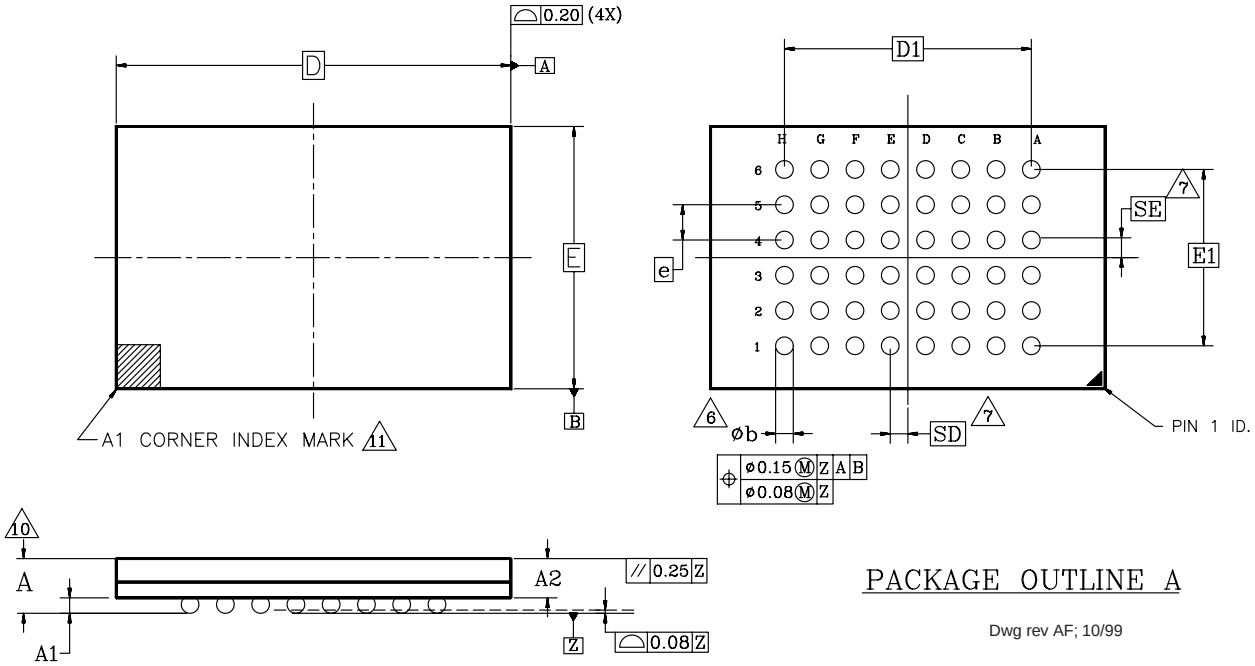
Note: *Includes all pins except V_{CC}. Test conditions: V_{CC} = 2.0 V, one pin at a time.*

DATA RETENTION

Parameter Description	Test Conditions	Min	Unit
Minimum Pattern Data Retention Time	150°C	10	Years
	125°C	20	Years

PHYSICAL DIMENSIONS

FBA048—48-Ball Fine-Pitch Ball Grid Array (FBGA)
6 x 8 mm package



PACKAGE OUTLINE A

Dwg rev AF; 10/99

PACKAGE	xFBA 048			
JEDEC	N/A			
	6.15mmx8.15mm PACKAGE			
SYMBOL	MIN	NOM	MAX	NOTE
A	—	—	1.20	OVERALL THICKNESS
A1	0.20	—	—	BALL HEIGHT
A2	0.84	—	0.94	BODY THICKNESS
D	8.15 BSC			BODY SIZE
E	6.15 BSC			BODY SIZE
D1	5.60 BSC			BALL FOOTPRINT
E1	4.00 BSC			BALL FOOTPRINT
MD	8			ROW MATRIX SIZE D DIRECTION
ME	6			ROW MATRIX SIZE E DIRECTION
N	48			TOTAL BALL COUNT
b	0.25	0.30	0.35	BALL DIAMETER
e	0.80 BSC			BALL PITCH
SD / SE	0.40 BSC			SOLDER BALL PLACEMENT

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M–1994.
2. ALL DIMENSIONS ARE IN MILLIMETERS.
3. BALL POSITION DESIGNATION PER JESD 95–1, SPP–010.
4. e REPRESENTS THE SOLDER BALL GRID PITCH.
5. SYMBOL "MD" IS THE BALL ROW MATRIX SIZE IN THE "D" DIRECTION. SYMBOL "ME" IS THE BALL COLUMN MATRIX SIZE IN THE "E" DIRECTION. N IS THE MAXIMUM NUMBER OF SOLDER BALLS FOR MATRIX SIZE MD x ME.
6. DIMENSION "b" IS MEASURED AT THE MAXIMUM BALL DIAMETER IN A PLANE PARALLEL TO DATUM Z.
7. SD AND SE ARE MEASURED WITH RESPECT TO DATUMS A AND B AND DEFINE THE POSITION OF THE CENTER SOLDER BALL IN THE OUTER ROW. WHEN THERE IS AN ODD NUMBER OF SOLDER BALLS IN THE OUTER ROW PARALLEL TO THE D OR E DIMENSION, RESPECTIVELY, SD OR SE = 0.000 WHEN THERE IS AN EVEN NUMBER OF SOLDER BALLS IN THE OUTER ROW, SD OR SE = e/2
8. "X" IN THE PACKAGE VARIATIONS DENOTES PART IS UNDER QUALIFICATION.
9. "+" IN THE PACKAGE DRAWING INDICATE THE THEORETICAL CENTER OF DEPOPULATED BALLS.
10. FOR PACKAGE THICKNESS A IS THE CONTROLING DIMENSION.
11. A1 CORNER TO BE IDENTIFIED BY CHAMFER, INK MARK, METALLIZED MARKINGS INDENTION OR OTHER MEANS.

REVISION SUMMARY

Revision A (November 9, (2000)

Initial release.

Revision A+1 (November 8, 2004)

Global

Added cover page

Added Colophon

Updated Trademark

Added referenced links.

Ordering Information

Added temperature range for Pb-free Packages

Valid Combinations for FBGA Packages

Added new order number information

Added new Package Marking information

Colophon

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